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EDUCATION AND TRAINING OF THE CHEMIST

The Conference called by the Institute to consider "The Education and Training of the Chemist" was held in the William Beveridge Hall, the Senate House, University of London, on 26 October.

The President, Dr D. W. Kent-Jones, expressed his pleasure that Sir Ian Heilbron, D.S.O., F.R.S., who has had wide and long experience in all sides of the questions discussed, had been able to accept the Council's invitation to take the Chair. He also reminded those present that the full text of the papers had already been published (*J.*, 496-517).

Sir Ian mentioned that he had been associated with the Institute for just on fifty years, half the period since Dr Moberly (*J.*, 513) said that it was inconceivable that chemistry could ever become a normal school subject. It had recently been stated that the annual output of scientists and engineers would have to be doubled by 1970 (*J.*, 753), and the burden of this task would fall on the universities, colleges and schools. A review of education and training requirements was therefore opportune.

He then referred to previous discussions of a similar nature, particularly the Conference of Professors of Chemistry, under the chairmanship of Professor Meldola, in 1913, and the Conference with representatives of the Association of University Teachers, the Chemical Society, the Science Masters' Association and the Society of Chemical Industry in 1943. Many of the suggestions put forward at those conferences had since been adopted.

Sir Ian reminded the Conference that, in the matter of trained scientists, we started with very few in the first world war, but that then and since the universities had met every demand made of them. Now, he said, chemists hold important administrative positions in government service, the universities and technical colleges, in industry and in many other fields. He welcomed these developments, but added the warning that, at all costs, we must avoid the "relentless creation of a nation of specialists."

Dr Norman Booth, presenting the views of a number of industrial representatives, claimed that the final year of a university course brought the student to the frontiers of knowledge and was designed primarily for those who were likely to proceed to a higher degree or to take up fundamental research. He said that in their opinion there should be an alternative course of equivalent standard for those who would make their careers in industry, that is, for the majority, aimed primarily at training the student in seeing how practical problems are tackled and giving him practice in tackling them (*see J.*, 499).

Sir Owen Wansbrough-Jones, K.B.E., C.B., reiterated his view that the Government was in the main satisfied with its recruits and with the training they had received, and said that a sense of discipline and cost-consciousness was of first importance. He added that the right cognate studies (usually physics and mathematics) seemed to produce more useful recruits, and he emphasised the value of attending additional short courses on special techniques.

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Professor E. G. Cox, T.D., F.R.S., thought that the universities could not entertain any considerable alteration in the kind of work they were doing, despite continual pressure from without. They could, however, do more to make students realise that they will have a heavy responsibility for running the country in the next generation. He agreed with Sir Owen about the need for a disciplined approach and thought that university teachers could do more to inculcate intellectual discipline and to train students in preparation for their future responsibilities.

Introducing his paper, Dr Edwards said that we must think in terms of the possible sources of students. Sir Eric James rightly stressed that the schools are the ultimate source. Dr Edwards was mainly concerned with those students who leave the Grammar and Technical schools at 16 or 18 to go into industry as technical assistants.

In addition there was probably an important latent source of supply among the best students from the Modern schools, though at present only a small portion even of those with the latent qualities required could hope to survive the full course.

It might well be that a number of students who now enter the universities would be more suited to technical college education.

The school leavers who enter industry at 16 or 18 and have the ability to attain professional status are probably comparable in numbers with those who enter the universities. Our present shortage of technologists and scientists is so severe, he said, that we must look carefully at the reserves of latent talent and character among laboratory assistants and technicians to make sure that they are not being wasted.

In the first place it must be noted that part-time day release is by no means universal throughout the chemical industry, though big advances have been made. It need hardly be said that it is wasteful for a young student of ability to have to undertake his or her chemical education entirely by evening classes.

Dr Edwards stressed that for the more able part-time students transfer to full-time or sandwich courses was the best method of ensuring the prevention of waste. In this respect it appears that the chemical industry is not yet showing the same initiative as the engineering industry. Undoubtedly there are difficulties about transferring technical assistants to full-time or sandwich courses, but they should be faced if we are to avoid losing a significant proportion of the potential chemists among them, either by their failing to graduate or by reason of the excessively narrow path they must take to graduation.

He said that Dr Booth's paper gave a number of excellent leads of particular value in considering sandwich courses in chemistry. For that large proportion of chemists whose work is of a technological nature, experience in industry is a vital part of their training, and there seemed to be a good case for the gradual assimilation of this experience over the whole period of their training.

Dr Booth had also made a case for an alternative final year in the course for the industrial chemist. Such an alternative year, involving the tackling of practical problems of a significant character, would be best appreciated by students who had already some contact with such

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problems from their own industrial experience. In the sandwich course the industrial experience could be a planned section of the training as a whole. It would therefore play an important part in the preparation of the student for a final year of the kind that Dr Booth has suggested.

The experience of those in industry and technical colleges would endorse this conception of a period devoted to training in the methods of solving practical problems. Undoubtedly many chemical concepts which remain abstract and intangible in the usual degree course take on a new substance and significance when used as tools in the solving of practical problems.

He claimed that there is a strong case for such a period preceding full-time employment as a graduate chemist, since the pressure of work and economic considerations inhibit the all-round training of the type required.

For the success of the kind of course suggested by Dr Booth, he thought two other things are necessary; first, there should be an adequate basis of fundamental science, and secondly the final qualification achieved should really command (in its own field) at least the respect accorded to an honours degree.

"I am inclined to think," Dr Edwards said, "that two years full-time study is too short for the fundamental basic scientific training. On the other hand, the first three years of a sandwich course, while not involving very much more college time than two years full-time study, permit the assimilation to take place over a longer period and in a less intensive way." In all the main fields of chemical theory the student could be expected to reach Graduate membership or honours degree level in such a period (starting at the G.C.E. Advanced or Ordinary National Certificate level), but it would be necessary to prune a good deal of the purely descriptive material out of the syllabus. The fourth year of a sandwich course could then be devoted to projects along the lines mentioned by Dr Booth, but such projects might best be found in some sufficiently broad yet reasonably defined field of specialisation which might be connected with the field of industry within which the sandwich student will be mainly engaged. One such field might be surface and colloid chemistry, another synthetic organic chemistry and pharmaceutical chemistry, a third that of analytical chemistry, and so on.

Such a course might well qualify for the award of a suitable Diploma in Technology recognised by the National Council for Technological Awards. The relation of the Institute's own Graduate membership and Diploma qualifications to sandwich courses also needed to be examined.

Finally, Dr Edwards referred to the question of the place of the humanities in the education of the chemist. Here he was thinking of the contribution that education made to the preparation of the whole man, for whom the understanding of his fellowmen and the way they move in the stream of social history and culture was of equal importance to his command of techniques.

This shaping of the man is a task more readily accomplished by life in the round than by formal education. However, education could provide some of the tools. These might include an introduction to great

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literature and an insight into the different disciplines of the social sciences. The seeds must be laid at school, but they would flower only when the student's contact with social life began to show their relevance. It would seem worthwhile to explore their place in sandwich courses, where the blend of the academic life of a college with the social life of the factory could produce in the student a quickening of interest in affairs that lie outside the narrow discipline of the laboratory.

Sir Eric James emphasised that in output of high-grade scientists and technologists combined, this country stands higher than any other in Western Europe, and a considerable proportion are chemists. The schools were not therefore doing too badly.

As regards quality, he pointed out that through the Science Masters' Association, and in other ways, school syllabuses and methods are constantly under review, though some 'A' Level syllabuses still stood in need of pruning. Chemistry, however, was a subject that it is particularly easy to teach in a dull and unimaginative way. It is, therefore, particularly dependent on good teachers, and the shortage of such teachers is by far the major problem of scientific education today.

Sir Eric said that there was one particular point of method on which he feared he might be misunderstood. "I suggest that as an experiment practical *examinations* at 'A' Level should be abolished. This is not because I undervalue practical work. It is precisely because I attach so much importance to it that I am afraid that the practical examinations of some examining boards may lead to a dreary and unthinking approach to that part of the subject which should most develop initiative and independent thought."

He also emphasised that many schools are hampered in their teaching by inadequate laboratory space and assistance. To get value for the money which is being devoted to chemical education in universities and technical colleges, we must ensure that there is likewise a reasonable expenditure at the school level.

The problems of specialisation and general education are much more complex than are often supposed. It was of first importance that in the pursuit of general education we should do nothing to destroy the genuine achievements of our sixth forms; that we should not overload still further the curriculum by adding a great number of extraneous subjects; and that we should realise that, both at schools and in universities and technical colleges, the essential pre-requisite of general education is a certain amount of leisure for the student to read for himself.

Sir Ian Heilbron then briefly reviewed the major points brought out in the papers and asked for any observations from the floor in the short time that remained before the interval.

During the preliminary discussion, Dr Frank Hartley reinforced Dr Booth's suggestions, pointing out that the Conference should not consider merely how to make the good man better. "Outstanding men will always seize their opportunities." Attention should be turned to improving the quality of that much larger number, perhaps 90 per cent of potential chemistry graduates, of what had been called 'solid beta men.' Industry's needs could not be dismissed in terms of technicians or chemical engineers. Industry needed its share of first and top seconds in chemistry, but it also needed a much larger number of chemists.

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Mr Gomer Davies put in a plea for the presentation of a qualitative picture of atomic and nuclear phenomena as the normal approach to chemistry from the middle school upwards. He also asked for facilities for teachers to attend courses such as those arranged by the Isotope School, Harwell, and suggested that some of the Institute's Education Fund might be used for such purposes. Further, a sponsored 'circus' demonstrating modern techniques, might visit the schools. In order to stimulate scholars more in thought, a more provocative type of question in the practical examinations for the General Certificate of Education could be set. He also criticised the usual university lecture system and deprecated voluminous note-taking at great speed. The student, he thought, should be supplied with typed précis notes and sources of information should be given. The standard of attainment of the average beta student was, he thought, affected by the tendency for university lecturers to be selected primarily for their research capabilities rather than for teaching ability.

Miss J. L. Scott then pertinently remarked that no speaker had mentioned the training or need for women as chemists in industry. A recent Government White Paper stated that "only small numbers of girls at present decide to study science or mathematics at the universities or training colleges. It is in the national interest that more should be encouraged to do so." "Is it only the opinion of the Government," she asked, "or does industry also agree that more women are needed?"

DISCUSSION

After an interval for tea, the discussion was opened by Professor T. S. Wheeler, the Chair being taken first by Sir Ian Heilbron and later, after a second interval, by Dr J. W. Cook, F.R.S.

Professor Wheeler stated that there was no disagreement about the education of a chemist. All wanted the universities and similar institutions to produce a life-long student; a man who, apart from his knowledge of chemistry, would have acquired habits of study and be able to teach himself. It was with reference to the training of a chemist that differences of opinion manifested themselves. In any consideration of the subject it must be remembered that the flexibility of the human mind made it difficult to determine the best method of training. The first-class students scarcely needed to be taught, the bad ones resisted teaching. It was the sound plodding second honours type that posed the problem. He did well with good teaching and badly if wrongly taught. The basic difficulty in teaching chemistry lay in coping with the growing flood of chemical knowledge. There were grave objections to increasing the length of the course, but inevitably it would be necessary to follow the example of the doctors and add a year to the requirements for a special degree. The extra time could be regained by permitting a student with this additional training to proceed to a Ph.D. degree after two postgraduate years, since in the final undergraduate year there could be more specialisation and some training in the methods of research.

It should be remembered, Professor Wheeler continued, that in 1920, when he became an A.I.C., a four year day-course in chemistry was an essential for admission. This training time still remains. Apart from the increase in factual knowledge since 1920, much of which might be ignored, there yet remained a great deal of new material of basic importance—quantum theory, atomic and molecular structure, stereochemistry—which had to be presented to the student. Room for modern

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developments could not be made merely by dropping older material from the course. Further, a modern student of chemistry required a much greater knowledge of physics and mathematics than did his counterpart in 1920. There seemed, therefore, no escape from a longer course of training.

It was clear, however, from the present climate of opinion that no addition to the current length of course would be tolerated in the near future. In the meantime one must seek to make the best use of the time available. It might be that in University Departments of Chemistry research was promoted to the detriment of teaching. More attention could profitably be given to improving the presentation of material. It was essential that courses be linked to avoid overlapping so as to utilise the undergraduates' time efficiently. As far as practicable, modern knowledge must be fed back to the first year and basic unifying theories, such as the quantum mechanical theory of valency, introduced at an early stage. In this way chemistry would be presented without too much emphasis on memory work.

There might also be scope for saving time in a reorganisation of practical courses. Some of these courses still seemed to be based on the idea that a student when he graduated would become an analyst. The emphasis should be on physico-chemical experiments designed to illustrate principles. The teaching of odds and ends of subjects with little intellectual content was to be avoided. Suggestions in this respect had ranged from public speaking to fire prevention. Nevertheless, all proposals for improvement in the teaching of chemistry were palliatives; sooner or later a year would have to be added to the normal honours degree course.

Professor Wheeler referred to the necessity for watching standards when a large number were seeking to enter the profession. Mere practical skill was not sufficient to justify admission. Intellectual capacity must be the criterion.

Professor Wheeler concluded by saying that a graduate chemist who had studied physics and mathematics, and some physical and inorganic chemistry, and who had a sound knowledge of electronic theory, of the reactions of functional organic groups, of stereochemistry and of the more important organic techniques, would not at once be a steroid chemist, or an alkaloid chemist, or a protein chemist, or a carbohydrate chemist, but he would be so trained that he could take up any one branch of organic chemistry with a versatility and success impossible to a chemist trained manipulatively but with a restricted theoretical background.

THE NEEDS OF INDUSTRY

Mr R. C. CHIRNSIDE: I want to refer to one or two matters arising from the authors' summaries of their papers. Some things we have heard seem to give point to some of Dr Booth's remarks (*J.*, 498).

Both Professor Cox and Sir Eric James made it clear that in their view only a small proportion of the students with whom they have to deal are of first-class mental ability and that, even with the increase in numbers of recent years, a large proportion are good second class (or, as they have termed it, beta class) ability.

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Now we all recognise and admire scholarship; we want to nurture it and provide it with the conditions in which it can flourish. The speakers have themselves indicated that such men are likely to grow in knowledge and stature whatever course the University provides. Is the present curriculum suitable for all these other beta students? I think it is Dr Booth's view, and I would support it, that industry is interested in scholarship; it is interested in new knowledge. Industry needs it, wants to understand it and to apply it, but there are some limitations to the rate at which this can be done. But this is not the only task of industry—it has also to make effective use, and indeed more and more effective use, of existing knowledge in the day-to-day business of manufacture.

My late chief, Sir Clifford Paterson, used to emphasise that one of our main objectives in an industrial research laboratory should be to bring scientific thinking into industry on the factory floor. For this we need many kinds of chemist, besides the exclusive type envisaged by Professor Wheeler. I would strongly repudiate Professor Wheeler's extraordinary suggestion that the others are not even chemists and just as strongly support Dr Booth's view that the man whose business it is to apply chemistry (and often even wider scientific principles) to the complex problems that arise in industry is required to display intellectual ability of an equal but possibly different type.

As Dr Hartley has pointed out, if we do not get enough of these men, industrially and nationally we shall be in a serious plight, and the financial support which industry helps to provide for scholarship will be in jeopardy.

Dr D. C. GRIFFITHS: The most stimulating of the papers presented was that by Dr Booth. It was stimulating because he had the courage to make concrete and specific proposals. In particular, he suggested the provision of an alternative course for the third year Honours B.Sc. student who intends to take up an industrial career. I venture to infer from this suggestion that there is a gap between the qualifications of the university graduate and the requirements of industry, particularly for those who are to be engaged in production, sales and administrative work. Statistics quoted indicate that these categories represent a very substantial proportion of the number of chemists employed.

In view of their close contact with industry and the ready co-operation of industry in providing the services of part-time teachers, many technical colleges are singularly well fitted to provide courses of the type suggested by Dr Booth.

Professor Cox sees a need for extending the university course to four years. An alternative would be to provide a common three-year course for all students. Those wishing to take up research or some other academic career would require another year of pre-research training. This could well be a postgraduate course. Others would enter industry at this stage and continue their studies on a part-time day release basis in the technical colleges. The emphasis in such courses would be on practical problems. The suggestions made in some detail by Dr Booth will form a good basis for formulating their content.

It would be valuable for university graduates to have this contact with the technical colleges, and such a scheme would stimulate still closer co-operation between the technical colleges and industry.

CHEMISTS OF ALL TYPES NEEDED

Dr P. C. L. THORNE: The Conference should really deal with the education and training of chemists, not of *the* chemist, who has been constantly referred to as a superior being. What are wanted are not a few of these Cadillacs but cars of all types. As I see it, the training of chemists should resemble a tree, with many branches coming from it at various heights and in many directions, to supply the needs for all kinds of chemists, pure and applied. Hitherto it has been too frequently the custom to give the student of applied chemistry the first part of a long course in pure chemistry and hope that he can make use of it. But this is not always what he requires, as applied chemistry often uses advanced techniques, both practical and theoretical, which the student does not meet with in the early part of the course. It was for the Institute to decide which of the great variety of chemists could be considered to be qualified chemists.

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SANDWICH COURSES

Dr J. H. SKELLON: Sandwich courses, in addition to part-time day courses, are likely to become increasingly important in the education and training of the chemist in technical colleges. In such courses the entrant at age 18 should hold either a good National Certificate or Advanced Level in chemistry and at least one other science, or mathematics; he would take a four-year course with alternate periods of six months in college and industry. The chemical industry—unlike the engineering industry—is faced with a new type of training for its employees, and, apart from tradition, there might be some difficulty in finding the students, owing to the more limited laboratory staffing. Whereas it is apparently possible for engineering firms to provide numbers of trainees for sandwich courses, it is undoubtedly difficult for a chemical firm to release more than one or two of their assistants at one time. Possibly it might help industry if colleges ran consecutive sandwich courses with five months in college and five months in the works; this would permit a firm to replace an employee coming to college by his opposite number, but of course it means more staff. Technical colleges are anxious to co-operate in these courses and the present difficulties of industry are appreciated.

A second important point is the duration of these higher technological courses. I strongly support the proposal that these courses should extend over at least four years. This is essential if candidates are to reach honours standard, which, I understand, will be required of candidates for the new Diploma in Technology. The technologist of the future, be he engineer or chemist, must be able to collaborate on equal terms with his partner, the graduate, in either research or production, and he will therefore require a thorough knowledge of pure chemistry, whatever his specialist applied field.

The continuation of the training of the young chemist on a sandwich course during his periods in industry is also a matter of profound importance, in which there must be the closest possible co-operation between colleges and industry.

At this stage, however, technical colleges initiating these courses are anxious to experiment, and the views of industry on the many aspects of such courses would be most welcome.

Dr G. TOLLEY: I am encouraged by Dr Booth's advocacy of a chemistry course having an alternative final year of study, involving an introduction to the application of fundamental principles to aspects of practical industrial development. Two years ago I proposed just such a course based upon the sandwich principle. The course is of four years' duration, with six months out of each year spent in full-time study at the college. The final year of the course follows the ideas put forward by Dr Booth. At that time the Education Committee of the Institute adopted a decidedly lukewarm attitude to the course as a whole. On the other hand industry picked upon this feature as being most valuable, particularly in relation to a sandwich course, which allows the student to have a more thorough appreciation of applications of chemical principles in industry.

We have heard criticism from Professor Cox that such a course might lead to undue specialisation and the production of a special sort of chemist. I am not convinced that such a course is different in essentials from the final Honours year at most universities, which ensures that the better student is allowed an opportunity to apply fundamental principles in one particular field—be it X-ray crystallography, polysaccharides or what have you.

Sir Eric James has said that expansion of numbers of students in science courses depends largely upon the encouragement of 'the good solid beta type.' It is in dealing with such students that sandwich courses show their merits. Let it not be concluded, however, that the product from these courses is second-rate. One Company sending sandwich students to my own Department is committed to an expenditure of about £30,000 per year for their support. That Company does not anticipate the second-rate man for an outlay of that magnitude. Neither do the National Council for Technological Awards or the Colleges of Advanced Technology, both of which are prominent in the development of such courses. They will want a man who can take the fundamental principles and the recent

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advances and put them to work in industry quickly, reasonably and efficiently.

Above all, perhaps, collaboration between college and industry in sandwich courses has ensured that the student, when in industry, will be thoroughly trained. No longer will he be regarded as the ubiquitous lab. assistant. Active co-operation between college staff and senior staff in industry in arranging the continuing course of training ensures that every sandwich course student is given full opportunities for development.

I would have liked to have seen another paper presented today and that is one entitled "The Position of the Royal Institute of Chemistry." Perhaps that will come as a result of this Conference. Bold and imaginative experiments are being made in the education of the chemist, in which industry and technical colleges are forging a partnership which will supplement the efforts of the universities in meeting the country's needs for chemists. That partnership needs the active support and encouragement of the Institute if it is to come to full fruition. The standards adopted by the Institute for its grades of corporate membership must be maintained and jealously guarded at all costs, but this does not preclude encouragement of new courses of merit now being evolved. A policy of 'wait and see' might well prove disastrous.

QUANTITY AND QUALITY

Dr FRANK HARTLEY: Industry, I repeat, needs a much larger number of chemists. It seems that they may not satisfy Professor Wheeler's conception of the right academic standard but they would be valuable chemists to the community. Professor Wheeler questioned the necessity for much of the practical work in their training. What a shocking thought! Chemistry is and must remain a practical science. It must not be allowed to become merely a philosophical subject. The application of experimental techniques and their development can never be left to technicians only. That is one reason why the proposals in Dr Booth's paper deserve serious consideration—proposals whose merit must not be obscured by argument about duration of courses. Another reason follows from a consideration of the scope of courses for externally assessed examinations—a matter of much importance to the Institute. Examinations inevitably influence teaching and training. It is becoming increasingly difficult for other than outstanding students to cover the ground of chemistry. Internal students are aided in being given a selection of glimpses of the boundaries of chemical knowledge but it is much more difficult for such a selection to be made by or for external students. Alternative approaches to those at present applied seem inevitable. To be specific and provocative, I should like to encourage discussion of the possible merit of divided approaches. Study might be based on physical chemistry, with a selection between inorganic, with its exciting new developments based on structural study and knowledge, and organic chemistry. At least such a division would permit for many potential chemists the kind of alternative inclusions outlined in Dr Booth's paper and provide some time for efforts to widen culture.

ARE THERE TOO MANY DEGREE STUDENTS?

Dr H. J. BARBER: It seems to be taken for granted by all the various august bodies who advise the Government on these matters that industry wants more university-trained scientists, as we at present understand the term, but it may be questioned whether it is desirable to attempt to put more and more people through the present university courses. Are there enough people of sufficient intellectual calibre to justify diluting the teaching capacity of the universities and colleges of technology which could perhaps be of even greater service if it had fewer numbers of higher average quality students to teach? The chemical industry needs many more sound beta men—it should not seek to skim the intellectual cream for itself. Too much of it concentrated in one place is apt to turn sour. It may also be asked whether university-trained scientists are used as economically by industry as they should be. The chemical industry has been criticised for being behind the engineering industries in the matter of sandwich courses; but it is at

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present neither equipped nor organised to carry the considerably increased number of young student chemists that would be necessary if they were to do the work at present done by those working four days a week with one day release for study. Moreover there are not enough young men and women coming forward for such work. I believe that many at present going to universities could, with advantage to themselves, to the universities and to the chemical industry, enter courses in which much of the training is done while they are on the job in industry and in which the education is done outside at colleges of technology or technical colleges. Sandwich courses could then play a proper part. I believe Dr Booth's new alternative third year should be considered as essentially a postgraduate year. Advanced or specialised technology should surely come after the university degree and need not necessarily be at the same university or college. It might be taken at a college of technology as an alternative to the overdone Ph.D. research work.

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REQUIREMENTS OF INDUSTRY

E. M. LEARMONTH: Before coming to the main topic to which I wish to contribute, I want to take up two minor points raised by previous contributors to the discussion.

Professor Wheeler has said that unless candidates come up to the standards set by the universities, they have no right to call themselves chemists. I do not accept the universities' claim to define a chemist. The only people who can decide whether a man is fit to call himself a chemist or not are the Council of the Royal Institute of Chemistry.

Secondly, he has hinted at some doubts about the usefulness of the three-year Ph.D. I think the demand of industry for people who have spent three years on a research course is extremely small. Industry, in general, does not want people who have specialised in a single narrow channel of learning and have come out to the much-talked-of frontiers of knowledge, passed through the sense-barrier, and toppled into the abyss beyond.

A former speaker hesitantly asked whether perhaps there was some small gap between the product of the university and the requirements of industry. There is not a small gap: there is a howling wilderness. There are still too many graduates coming out of the universities who look, behave, and no doubt feel, like fish out of water when they come into industry; and this brings me to my principal topic.

When I say 'Industry,' I mean industry composed of the enormous number of small firms which are still responsible for the greater part of the productivity of this country. They are the people who do employ, or should employ, the greater proportion of industrially employed chemists. Their requirement is, in general, not for the brilliant highly trained specialist—the three-year Ph.D.—but for a good all-round man who has been trained to think. If we are to have 85,000 more scientists in the next ten years, and if the 'bulge' in the schools, about which we hear so much, is ultimately to find employment in industrial science and technology, clearly, there are going to be a great many more of the moderately bright—the so-called good betas—seeking courses of training. My opinion is that they should not be trained as specialists, but given a sound grounding in chemical principles and thereafter trained to think. What are they being trained for? They are being trained to be of the best possible use in helping this country to maintain itself in commercial competition with the rest of the world. Let us remember that industry is not just the chemical industry: it is the food industry, the agricultural industry, the cosmetics industry—and dozens of others. If they touch the frontiers of knowledge at all, they touch it in very different places. What they do have in common is the need for men who have been trained to think.

Professor Wheeler has asked if the Honours degree course might be streamlined. I should prefer to see it disembowelled, and its present high content of odd and often unimportant facts replaced by a logical sequence of fundamental principles that the student is trained to use in his thinking. Because what industry wants more than the scholar is the man who has been taught how to think.

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REPLIES OF INVITED SPEAKERS

Professor WHEELER: I realise the importance of practical training in chemistry but I still think that time would be wasted in teaching the student to carry out analytical work with an accuracy approaching that of a routine analyst. A chemist supervising technicians need not be able to do each of the operations he supervises better than the expert—'a man who drives fat oxen need not himself be fat.' A chemist should of course know the theory of an operation and the manner of performing it, but this does not necessarily require him to have great manipulative skill.

I reiterate my belief that entry to the profession of chemistry must depend on intellectual calibre. The results of the Institute examinations show that many are seeking entry to the profession whose intellectual ceiling is below that corresponding to an honours degree, and no amount of manipulative ability can compensate for this deficiency. A man can be a chemist and yet find difficulty in estimating accurately a solution containing copper and iron, but the converse does not hold.

I think a chemist should not be kept on routine work proper to technicians, and I suggest that industrialists might well examine the use they make of chemists to ensure that professional staff are employed only on professional work.

During the discussion the universities have been exhorted to train people to think. I doubt very much if students can be *taught* to think; they either know how to think or they do not. The best a teacher can do is to instil a love of knowledge, and to develop in the student the ability to teach himself. To do this, however, one requires students of a sufficient intellectual calibre.

I agree with those who hold that in making university appointments too much emphasis is placed on research achievement and too little on teaching ability. I concur with those who point to the difficulty of external examinations when there is no syllabus to guide them. Both examiners and students should have a reasonably precise statement of the course covered by the examination and should not have to depend on previous examination papers. Papers become stereotyped, as examiners hesitate to vary the nature of a paper lest they should be unfair to the students. On the other hand there is perhaps a tendency to too great novelty in university examinations, so that this year's research papers become next year's question papers. Finally I would stress my belief in the necessity for the addition of another year to the course for a special degree.

Dr BOOTH: I should like to refer to three points which have been raised in the discussion.

Firstly, Dr Griffiths asked if there is a gap somewhere between the student's instruction and his ability to start on a practical job in industry. When one is dealing with a question like this it is dangerous to generalise, and there is no doubt that some graduates can immediately begin to apply the knowledge and techniques they have acquired. In many cases, however, and perhaps in the majority of cases, this is not so; not infrequently the graduate cannot tackle the simplest matter without detailed instructions.

Secondly, on the question of sandwich courses in chemistry and engineering, I think that it may often be more difficult for chemical firms to arrange to fit in with sandwich courses than it is for engineering firms, partly because of the type of work on which their young men are engaged and partly because of the smaller numbers of such people on their staff. In addition, the tradition and outlook of the chemical industry as regards the education of their younger staff are, in general, rather different from those of the engineering industry.

There has, I think, been some misunderstanding of the alternative course suggested in my paper. It is not meant to be a course in which the principal objective would be to absorb facts about industrial processes but rather one which would show how principles are applied. It is not suggested that the student need choose between the alternatives until the end of his second year, by which time he and his supervisors should be able to judge which type of course he is more

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suited for. Again, it is not suggested that all universities or technical colleges should be expected to provide this alternative course, at any rate in the first instance. It is, however, suggested that it would be advantageous for some courses of this type to be provided. It has been criticised on the grounds that more than two years would be necessary for instruction in basic principles and techniques; it may be that when one came to work out the full details of a course of this type this would be found to be the case, but the policy of having a course showing how chemical principles are applied is not, in my view, affected by this point.

Professor Cox: Proposals for alternative courses (*e.g.* 'academic' or 'applied') in the final year of an honours degree course are made on the assumption that by the time he starts his final year, the student has been sufficiently grounded in fundamentals to be allowed to specialise and that he is sufficiently certain about his career to make a sound choice between the alternative courses. In my experience these assumptions are very wide of the mark. Students who have reached the final year of an honours course in pure chemistry are those who decided on entry to the university that they preferred to take a specialised course in pure chemistry rather than in one of the various kinds of applied chemistry on the one hand or in general science on the other, and who have not wished nor have been compelled to change their minds in the succeeding years. This does not mean that they all wish to be academic chemists: many of them take the view that they do not wish to commit themselves until they are very near graduation, and that they want an all-round basic training in chemistry to give them the widest subsequent freedom of choice. In their final year they will have many interviews with their professors and tutors, with university appointments officers and with prospective employers; during that year their views about the future will crystallise, in many cases changing a good deal in the process. Some employers will suggest that a man should have a period of postgraduate research before taking up employment and others will try to secure the man they like as soon as national service permits, but in any event two or three years' postgraduate research does not commit a man to a particular type of employment, whereas a course of training in industrial chemistry at the undergraduate stage is very liable to do so. The figures for my own experience in the field of X-ray structure analysis, which is undoubtedly a highly specialised 'academic' topic and therefore unfavourable to my argument, show how little research restricts a man's subsequent career. Excluding those not yet settled, those of overseas origin and mature students who were already committed to a career before they came to my department, I have had to date 22 postgraduate students in X-ray crystallography, 11 before the war and 11 since. Of these, 6 are in universities, 1 is in a technical college, 3 are school-teachers and the remaining 12 are in industrial employment. At the present time 6 of these 12 are engaged almost wholly in research, 5 of them in X-ray crystallography, but only 1 of these is from the pre-war group, and it is certain that the younger post-war students now doing research will in due course pass on to other types of work and some of them, like the older ones, will become plant managers and so on. Incidentally it should be noted that the figure of 3 out of 22 (2 out of 11 since the war) entering the teaching profession compares favourably with the proportion for all science graduates, and shows that it is wrong to assume that a student going on to postgraduate work is lost to teaching.

Dr Tolley asks what difference there would be in principle between a final year with an industrial emphasis and one biased in a particular academic direction, *e.g.* towards one of the research interests of the department. While I would not dissent from Dr Booth's view that an industrial course could make considerable intellectual demands, I think that in general a specialised academic course would have the merit of stretching the students' intellect more: nevertheless my opinion is that marked specialisation in any direction at the undergraduate level is bad and that industrial chemistry and X-ray crystallography alike are subjects for postgraduate lectures. The final year of the undergraduate course is needed to round off the work of the previous years, and if there were room in it for specialisation on a major scale then the course would be unnecessarily long for achieving

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the primary objects set out at the beginning of my introductory paper. No-one today could seriously maintain that our courses, whether three- or four-year, are too long, either by comparison with Continental universities or with our own courses in the past. I feel that Dr Cook is a little misleading in suggesting that the universities have effectively gained a year by transferring the old Intermediate first year to the schools; this happened at an earlier stage, but there has been no such change to correspond with the enormous growth of scientific knowledge since the end of the first world war. I and many of my contemporaries in 1924, for example, took the London Intermediate B.Sc. examination at school and went on to a three-year course at a university.

While I do not doubt that examples of excessive academic specialisation can be found, I believe that the critics greatly exaggerate its extent and fail to discriminate between the teaching of principles and the general discussion of results on the one hand and the excessive preoccupation with detailed techniques on the other. Many of the topics which take the student 'to the frontiers of knowledge,' and in which his teachers are active researchers, are vitally important for enlarging both his understanding of principles and his knowledge of results which he may be called upon to apply in industrial or academic employment. It is also perhaps not recognised that the fact that most university schools of chemistry are now double- or triple-headed, with a very wide spread of interests, militates against excessive specialisation, and that the greater post-war mobility of graduate students offers opportunities for correcting any supposed bias in their undergraduate training; for example, of those graduates in Leeds who go on to research about a quarter go to other departments, and about half of those doing research in the school came from elsewhere.

Dr EDWARDS: The question of how we can obtain the students for sandwich courses has been raised. It must be agreed that there are difficulties about releasing laboratory assistants or technicians for these courses, since many of them play a more indispensable role in industrial laboratories than their counterpart student apprentices in engineering. However, these problems must be faced if the ability and potentialities of these students are not to be wasted. It is worth considering that the existence of sandwich schemes of training can be a powerful incentive to draw young people of ability into technical and scientific positions in industry. This is one of the objectives that the engineering industry has had in mind and the chemical industry might well learn from them. Arrangements are possible between college and industry to minimise any interference with industrial work. Thus it is possible to have the college part of the course in alternating five-month periods, so that the assistant who is on the course may be replaced by another who will alternate with him in industry and college. Unless the chemical industry can offer some prospect of this kind of wider educational opportunity it will not attract a fair share of the most able young people coming from the schools.

In the discussion on the alternative ways of training chemists there was a tendency to oversimplify the classification of students as α, β or γ types. However, more qualities are needed of the industrial scientist than can be expressed in terms of the initial letters of the Greek alphabet. Qualities of character are of particular importance (such as courage, persistence in endeavour and firmness in judgment). The normal academic course puts a premium on the ability to carry abstract concepts in the mind for a prolonged period with little contact with their application. There are other students whose path towards a deeper understanding of fundamentals can be made surer by frequent appeal to practical application and for whom scientific ideas attain significance mainly in the measure that they assisted in the solution of problems of real significance. Such students are precisely those likely to be most successful as chemists in many fields of industry. For students of this kind and for positions of this kind the experimental ideas of sandwich courses and the alternative final year proposed by Dr Booth seem to converge towards an alternative form of training of the chemist. This is not a question of a training suitable for β-class people, but an alternative mode of training capable of providing a quota of first-class chemists of their own kind, for whom the solution of practical industrial problems is their main interest.

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THE IMPORTANCE OF EARLY TEACHING AND PRACTICAL WORK

Dr G. D. MUIR: Reference has been made to the need to simplify the teaching of chemistry, and it seems to me that the time is now ripe to introduce the electronic theory of valency and a short account of nuclear particles and atomic structure at an earlier stage. Young people today are ^{235}U-plutonium-conscious, and an early glimpse of the facts behind nuclear energy, presented imaginatively, should be rewarding. So much taught about valency has to be re-taught later from a different angle, and this is both confusing and a waste of time. Close co-ordination of the teaching of physics and chemistry, especially when electricity and the electron respectively are considered, would be beneficial and reduce the early impression that these sciences are unrelated subjects without a common background. According to science masters with whom I have discussed this question, the G.C.E. syllabus sharply restricts their opportunity to experiment with this approach, and it is the responsibility of the universities to initiate any reforms.

The other matter that I want to speak about is the vexed one of practical work and practical examinations in the universities. In my opinion, both students and examiners attach far too little importance to practical examinations where these exist. The Institute has rightly set a high standard in its practical examinations, and it is unfortunate that similar requirements do not influence the award of university degrees. How many of us have found the young alpha graduate entering industry to be somewhat delta when given a job to do at the bench? If more weight were given to practical work, the student in his own interest would have to apply more self-discipline, and his English would improve if more were expected of his laboratory record books.

It is nonsense to say, as Professor Wheeler has done, that a graduate in chemistry need not be familiar with routine techniques normally carried out by laboratory assistants. By all means let university laboratory training be up-to-date and varied in its scope, but industry needs, above all, practical men of energy who know how to supervise the work of laboratory assistants and others with little theoretical background. To have the respect and confidence of his assistants, the chemist must be able to cope with analytical and preparative difficulties and to give sound practical advice and instruction where necessary.

Mr L. M. MIALL: I agree with the previous speaker's remarks on the teaching of practical chemistry, and think this so important that it is worth repetition. The average chemist has been shown to spend about half his time at the bench. And did Professor Wheeler seriously think that a chemist could satisfactorily supervise the practical work of assistants without ever having done such work himself?

It was said earlier that a healthy difference of opinion has been shown at the meeting, but the differences have tended to fall into two groups; the industrial chemists on the one hand, whose views are on the whole the same as those of the technical colleges, and the universities on the other, possibly supported by the Government Service. This difference of opinion is a very unfortunate one for the profession, and one that should not be. I am horrified that a Professor of Chemistry can say that it is not his business to teach people to think. I can imagine Professor H. E. Armstrong's comments on such a statement! Whose business is it, that of the schools?

ANCILLARY SUBJECTS

Mr H. MURRAY: It is a privilege to be allowed to speak, since I am only a tame Irishman, not a wild one like Professor Wheeler.

Much of the criticism directed against Dr Booth's paper has dealt with his proposed new type of course and his suggested short courses of lectures in other subjects have been ignored.

I think this is an excellent idea, though I should prefer these lectures to be spread over the three years. In addition to the compulsory subsidiary subjects there should be an ancillary one, a 'useless' subject such as one of those mentioned

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by Dr Booth, or perhaps logic, history or a modern language. I feel sure that the pursuit of such a 'useless' subject would provide excellent mental relaxation and thus refresh the student in his arduous chemical studies.

Professor Wheeler will remember that years ago—I don't know the position today—the University of Dublin insisted that its students of medicine, chemistry, physics and engineering should also read for an Arts degree, and the Royal College of Science for Ireland made all its students read the same basic course of arts and science subjects in their first year. Some of the most interesting discussions I remember from that year were not with any of the chemistry professors but with the English professor, on the poetry of Yeats. In spite of the extra work involved, the death-rate among the students of the University of Dublin and the College of Science remained remarkably low.

I cannot agree with Dr Edwards when he says in his paper: "One of the problems of liberalising the education of the scientist is to secure his interest in subjects that lie outside his immediate scientific orbit" (*J.*, 512). Students must have changed greatly since my own undergraduate days when we spent many hours talking about every subject under the sun—except, perhaps, chemistry.

Mr W. H. Moss: I strongly oppose sandwich courses. I am quite sure that a comparison of two assistants starting equal, the one taking the present standard of classes on one day and two nights for four years and the other taking the sandwich course, would show the first to be a more competent chemist and holding a better position at the end of the time.

I support those speakers who have asked for a better training for the chemist in purely chemical subjects. More time might be required, and this should be taken from the period between 17 and 20 years. When advanced G.C.E. has been obtained, any further work done say for a scholarship, is a waste of time, because it is all done again in the first year at the university—the more the student advances, the greater the overlap and first-year frustration.

National Service should be cut for chemistry students, and the whole of this 17-20 period left available for improved chemical courses.

THE TEACHING OF CHEMISTRY IN SCHOOLS

Mr G. Fowles: Largely owing to the activities of the Science Masters' Association, encouraged and helped by both academic and industrial chemists, the last 40 years have seen the healthy development of a better teaching of school-chemistry. Industry, by welcoming visits from groups of science masters, and by the gift of literature written by experts, is lifting teachers out of the textbook by providing them with first-hand knowledge of metallurgical and manufacturing processes. The hospitality afforded by the universities, both old and new, to the three-day annual conference of the S.M.A., the lectures and demonstrations in which the university staff give of their best, are likewise doing much to promote a more enlightened presentation of science. As a Past-Chairman, I should like, in the name of the S.M.A., to thank the leading university and industrial chemists for what they have done on our behalf, to say how much our members appreciate their help and to express the wish that they would continue or even extend their efforts.

Nevertheless, despite the optimistic note in Sir Eric's address, we must beware lest complacency creep in. For instance, neither his article nor speech contained any reference to girls' schools, although these could be the source of an abundant supply of chemists. Now the many girls yearning for a scientific career need the same training and must pass the same examinations as boys. Yet, in my limited experience, I find the time given to chemistry is shorter, and laboratory facilities and equipment inferior to those in boys' schools. Girls as a class, not being so endowed with originality, follow and adhere to a given technique more faithfully than do boys: a quality admittedly two-edged, but it could be advantageously utilised. If chemists in office as Governors, or called upon for advice, would use their influence to improve the conditions in these schools they would do much to augment the supply of potential chemists.

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FACTORS INFLUENCING SCHOOL CHEMISTRY TEACHING

Mr E. H. COULSON: In order to secure an increase in scientific man-power, the need for which is stressed in recent official statements, it will be necessary for the schools to attract a higher proportion of their pupils into Advanced Level courses. At present too many boys and girls (especially the latter), who could tackle more advanced work with success, leave grammar and technical schools at the age of 16. Although the wastage of really able pupils in this way is probably not large, it is none the less significant; but of much greater importance is the loss of large numbers of good average boys and girls who might easily provide the bulk of students for training schemes carried out conjointly by industry and the technical colleges.

There is no doubt that the attraction of a reasonably well paid job at the age of 16 is an important factor in preventing many pupils from remaining at school for a sixth-form course which involves two years of reasonably hard work, and the introduction of adequate maintenance grants for pupils undertaking Advanced Level work would have a decided effect in counteracting this. Financial assistance alone, however, will not solve this problem. If boys and girls are to be persuaded to devote their working lives to the pursuit of chemistry it must be made abundantly plain, *early in their school careers*, that, as Sir Eric James so pertinently remarks, its study is an exciting and stimulating experience. This cannot be done without an adequate supply of good teachers who will make the subject live in the minds of their pupils. Industrial and other organisations are producing an ever-increasing amount of excellent material, in the form of visual aids, models, specimens and so on, which can bring freshness and imagination into school chemistry courses, and a wealth of original ideas on the presentation of the subject has arisen in the past fifty years from the efforts of chemistry teachers themselves. It is a melancholy fact that a great deal of this valuable assistance is not used to its fullest extent in the schools; the reasons for this are an insufficient allocation of time to the subject and the lack of laboratory technicians and of a modicum of clerical assistance.

In too many schools the science subjects are still treated as 'poor relations' in the matter of the time devoted to their study in comparison with that given to other subjects in the curriculum. It is not uncommon, for example, to find that, up to Ordinary level standard, chemistry receives less than half the number of periods given to a language subject. This results in the proper and logical development of the subject becoming very difficult, demonstration and sheer memorisation replace individual practical work and the joys of discovery, whilst consideration of its application to everyday life and industrial progress are limited to incidental remarks.

The lack of trained laboratory technicians in schools is a stumbling-block alike to the efficient presentation of chemistry as a subject and to the recruitment of teachers. Improvement in this respect is distressingly slow, and the provision of suitable training courses for such technicians is necessary also. In addition, it is uneconomic and inefficient to deny a chemistry teacher access to some form of secretarial assistance in maintaining the contacts with suppliers of apparatus and chemicals and with industrial and research organisations which are necessary if his teaching is to be alive and his laboratory adequately maintained and equipped.

HIGHER NATIONAL CERTIFICATES IN APPLIED CHEMISTRY

Mr H. L. LONG: I should like to comment on the small number gaining Higher National Certificates in Applied Chemistry (16) in 1954, compared with 474 gaining Higher National Certificates in Chemistry. I fully agree that it is in the interest of those hoping to gain higher qualifications to avoid specialist application. The Institute, however, has always taken an interest in the training of the rank and file and, in my opinion, more of the large number who are not likely to get beyond a Higher National Certificate (this would be apparent to instructors at a sufficiently early stage) would be better advised to take this in Applied Chemistry.

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The Higher National Certificate in Chemistry involves the minimum of technical application. On the other hand, courses for City and Guilds' Certificates lay emphasis on the technological aspect. I should have thought there would have been a larger number taking the middle course in the form of National Certificates in Applied Chemistry. I can hardly believe there is not a substantial body of employees for whom the latter would provide a suitable objective, and I wonder whether the small number of certificates gained is due to lack of provision of such courses by technical colleges.

THEORY AND PRACTICE

Dr D. FINLAYSON: I wish to raise a point which has not been mentioned so far, namely whether it is possible to improve the education and training of the chemist by the adoption of new methods of tapping the accumulated knowledge and experience of chemists in industry. I suggest that at present much of this valuable knowledge and experience is lost, since there is no method of filtering it back to the university student, where it is most needed. I suggest that methods could be worked out for exchanging university lecturers and industrial chemists for two years, one year or even six months. I think this would benefit all four parties—the student, the university lecturer, the industrial chemist, and the industry in which he is engaged. If this scheme is thought to be too ambitious, I suggest that more use might be made of industrial chemists to give one lecture each term, not on a special subject, but on an item of the ordinary syllabus, while lecturers might spend some of their vacations in industry. I believe that university teaching would benefit by more practical experience, and industry by more theoretical knowledge.

Miss J. L. SCOTT: A previous speaker suggested that some part-time or sandwich-course students if employed by a small firm may be limited to only one branch of practical chemistry. This difficulty, however, may be overcome by a student attending a sandwich course and being college-based, when he or she can be placed with a different firm for each period in industry and thus obtain the widest possible training.

Reference has also been made to the fact that some firms find difficulty in procuring the right type of students for certain courses. I would like to appeal to industry for more propaganda in the schools, because I am certain that many suitable students enter the wrong occupation or training owing to the lack of knowledge of the opportunities that industry can offer.

BACKGROUND AND ANCILLARY SUBJECTS

Professor COX: I cannot too strongly emphasise my view that students of chemistry should have a thorough grounding in English language. To modify slightly some remarks of Mr P. Alexander (*The Times*, 19 October): "experience gained in teaching university students has convinced me that they require more, and not less, formal instruction in English. I say 'formal' because I am also convinced that the teaching at this stage ought to be designed primarily to increase skill in using our language by increasing detailed technical knowledge of it. We cannot train a person in precision and clarity in a particular subject without talking to him about that subject or ensuring that he reads the right books. But if he is not already competent in the use of our language, at home in its subtleties of syntax and meaning, the talking and reading will be wasted. Precision and clarity, as necessary in arts as in science, depend on skill in manipulating language which must be acquired but which cannot be acquired either by specialising in some branch of science or by practice in reacting appropriately to poetic expressions. I do not see how anyone can appreciate either chemistry or poetry unless he has first acquired this skill. The ability to think is very largely dependent upon the ability to use language: inability to use language hampers not merely the expression of our thought but our thinking itself."

Next in importance to English language among ancillary subjects for intending university chemists at school I would put mathematics. I believe that an understanding of mathematics to G.C.E. Advanced level is within the compass of anyone capable of taking an Honours degree in chemistry, but there is no doubt

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that many students, including some who have passed the G.C.E. Advanced level examination, come up to the university with a distaste for the subject which is very difficult to overcome. For such students it may be that a course in logic at the university would be acceptable as an alternative to further mathematics; certainly, in my experience, the failure of many students to grasp ideas in theoretical chemistry is due not, as they think, to the difficulty of the mathematics involved, but to their inability to follow a closely reasoned argument. Apropos of the remarks in my introductory paper about the need for streamlining courses, I should like to draw attention to an article by T. C. Fry in the *American Mathematical Monthly* for February 1956; Fry suggests that a good deal of streamlining of school mathematics courses can and should be done, to the extent of introducing calculus and the complex variable at the age of 15.

Dr Booth has suggested that universities could assist in the general education of students by organising their extra-mural activities, and Mr Murray has spoken of the desirability of 'compulsory useless subjects.' As universities are organised at the present time such proposals are quite impracticable, since students are treated as adults, and their right to organise their own affairs through their students' unions and in other ways is one which they guard jealously, and rightly so. It may be that they do not use their leisure to good advantage, but we must, as Sir Eric James has said, give them time to think and to develop in their own ways. I think that many of the complaints about present-day graduates stem from the fact that they are not able to use their free time properly, and this is perhaps because many of them, unlike pre-war students, are not of the first class intellectually nor have they come from homes which would have provided them with a background of self-discipline. It may well be that in fifteen years' time a much higher proportion of our students will come from homes where there is a better background because their parents themselves will be university graduates, and if this proves to be so they should be free of some of the faults which we see today. As I am inclined to agree with those who say that the culture of a student depends chiefly on his home and school environment before he reaches the age of 16, I am hopeful that, since the university population cannot go on increasing indefinitely, the proportion of students with non-graduate parents will diminish and that, correspondingly, their general cultural background will rise.

Owing to lack of time, a number of those present who had notified their intention to speak were unable to take part in the discussion. Their contributions, however, are given below.

STREAMLINING

Dr M. C. FORD: There is a considerable danger that with increasing 'streamlining' the way in which theoretical principles have evolved may progressively be lost to sight. Moreover, as Mr Fowles pointed out, the presentation of modern valency theory in simple terms makes exceptional demands upon the skill of the instructor. An inexpert and oversimplified treatment at too early a stage can bring about confusion rather than enlightenment. Again, there is nowadays a tendency to present reaction mechanisms as though they represented absolute truth rather than simply an approach to the truth, and, because time presses, to ignore the greater part of the experimental evidence upon which they are based. Although the importance of the electronic theory of reactions as an aid to correlating facts and giving unity to the subject can scarcely be overestimated, our enthusiasm to portray chemistry as an exact science must not cause us to forget that it is also an experimental one.

THE EDUCATION OF CHEMISTS AND THE COUNTRY'S NEEDS

Mr K. D. HUNT: In order that some real advantage may accrue from this Conference I should like to draw your attention to the following considerations. Different points of view on educational methods are all very well, but I would say —let us be practical; let us take first things first. The education of chemists is bound to be governed in the long run by two things, first by the human material

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available, and secondly by the needs of the country and the community. Official reports on this matter have already been published, but I propose to speak from my own experience as a chemist in industry. The recent Ministry of Labour Report speaks of a shortage of scientists in general. But what we want to know, and what it is, I suggest, the urgent duty of the Institute to make enquiries into and to report on is—what *kinds* of chemists and how many of them will be required in future years? Has this been done? Until it has been done we can only plan blindly. It would be most wasteful, for example, to produce men of high academic honours in chemistry if in fact there is no shortage of such men. I am not satisfied, from my own experience, that there is a shortage of honours graduates in chemistry, and I know from a perusal of advertisements that in general the professional chemist is too old at thirty and is practically excluded from a career in chemistry at age thirty-five or over. I feel that it may well be the case today that many honours graduates are performing work which could be done sufficiently well by people with lower academic qualifications. So I put this question to the Institute: "Is there a shortage of honours graduates in chemistry, and if not, is there a glut of them?" Please find out and tell us the position.

Turning now to another point raised by speakers, I think that the standards of our academic examinations must be maintained; because these standards are the crux of the examination system to which this country is committed as a method of deciding whether or not a man is qualified. To speakers who referred to those men who either have not passed or cannot pass examinations at university level, I would say this—by all means call these worthy people chemists. But what you must not do is call them *qualified* chemists, as, I regret to say, the Institute has already done in many cases.

With regard to the education of women to honours degree level and bearing in mind the time and money spent on such education, I think that the country would be most ill-advised, from an economic point of view, to take such women seriously unless there are reasonable prospects of their following a normal professional career, like men, instead of marrying and leaving the profession soon after qualifying.

EXAMINATIONS IN CHEMICAL EDUCATION

Mr H. R. JONES: I shall soon be paying the Institute an additional two guineas each year and understand that about half of that sum is to be devoted to extending the Institute's activities.

This payment will be worth while if it enables the Institute to take the lead in a thorough investigation into the methods of educating and training the student of chemistry.

We have heard something this evening of the 'examination bogy' and the evils of cramming but I think that our approach so far has been unscientific in that assertion and opinions have been expressed without being supported by experimental evidence.

We badly need a planned investigation of the part played by examinations in the mental approach of the student to his studies. When examinations are in the hands of those who have been intimately acquainted with the student over the period of his training, as is generally the case in the universities, one can quarrel little with the judgments made. Real harm may and does arise when examinations are external and a man is judged solely by a paper contact with his examiners. In such circumstances students tend to set their sights at the examination itself and eschew all activities which cannot be seen to lead to a high percentage mark therein. In other words we find 'Examsmanship,' with its accompanying statistical studies of old papers, and so on.

Many of the complaints that our students are not 'taught to think' may well be due to the fact that they are so busily engaged in committing a terrifying number of facts to memory that they have little time to think. More important, perhaps, many of them are convinced that the thinking approach does not pay. I have heard it said: "You can always get through on the memory questions—you might get stuck in a problem." If we wish our students to become thinking

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chemists we must set examinations which oblige them to use their brains, but there must then be a corresponding reduction in the amount of material to be memorised.

My colleagues and I have made a number of experiments along these lines in recent years by setting occasional examination papers in which candidates are allowed to use books of reference. The results have encouraged me to think that there is room for progress in this direction. In these tests one does not require the reproduction of syntheses or lists of properties of inorganic compounds but the questions are designed to test understanding of principles and ability to apply them. Similar problems have been devised for practical tests.

I am convinced that in the remodelling of our examination techniques lies the key to a renaissance in chemical education, and I look to the Institute to initiate and carry through a planned investigation in this field. I am sure that those who are engaged in teaching would wholeheartedly co-operate.

Dr R. F. PHILLIPS: The remarks of the four main speakers, and in particular of Dr Norman Booth and Professor Cox, although at variance with each other, support the results of an enquiry I addressed to major chemical firms in this country in 1954. Some firms held Professor Cox's view that intellectual integrity, sense of responsibility and training in discipline were the factors most looked for in new chemists. This group of firms appeared less concerned with breadth of knowledge and more that chemists should have a good grounding in fundamental science. The second and larger group, represented in the main by the firms of intermediate size, considered that the training of a chemist should include an introduction to such subjects as applied electricity, fluid flow, unit operations of chemical engineering, fuel technology and so forth. The Loughborough courses (sandwich and full-time) have in fact been designed to meet these requirements.

It is clear that a lead in this matter should come from the Institute. In particular, the nature of its Part II examination might well be reconsidered, since it largely determines the content of all courses organised in technical colleges. The universities are rightly less concerned with training a man for industry and more with advancing the boundaries of knowledge, and my comments do not therefore apply to these bodies. But technical colleges are very much concerned with industrial needs; they must keep abreast of these needs and must produce in increasing numbers the kind of men that industry requires. The challenge is a real one, and to help the technical colleges to answer this challenge I would suggest that the Institute Part II Examination scheme should be carefully scrutinised to see whether (*a*) too much is expected in the practical examination and (*b*) too much importance is attached in the written papers to the 'boundaries' of chemical knowledge. A reduction in the practical requirement, for example, would leave more time during a chemistry course for applied subjects to be taught; the Institute's present high standard of practical proficiency could be retained, however, by holding a more advanced practical examination, which might qualify for the award of a supplementary certificate of the Institute.

DO NOT LENGTHEN THE COURSE

Dr W. A. ROSS: It has been suggested that the present three-year course for a first degree (or Graduate membership of the Institute) should be increased in length. Such an increase should be opposed for the following reasons:

(i) There has been an increase in the length of most university courses very recently. This must end somewhere. It is impossible to turn out a graduate with a complete knowledge of any subject, however long the course.

(ii) A longer course would be an additional financial burden.

(iii) The present shortage of teachers and laboratories would be even more acutely felt.

(iv) The total number of chemists training at a given time would have to be correspondingly decreased, despite the present shortage.

(v) A four-year course would involve a loss of about 3 per cent of graduate working chemists.

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The main reason advanced for an attempt to lengthen the course is the much discussed 'gap' between what a student is taught and what an employer expects him to know. As a student can only assimilate a certain amount, this gap will always exist. What can be done to ensure that the present three-year course is more suited to the needs of employers and more beneficial to the students?

(i) Syllabuses for theoretical work should be drastically revised and should concentrate more on theories and methods rather than on purely factual knowledge. For example, in the field of natural products, two thoroughly studied examples of each type of compound of the main classes could teach a student much more than an endless number of syntheses. Almost all the factual knowledge of the present inorganic syllabus could usefully be shelved. How many students derive any material benefit from memorising the extraction of one of the rarer elements and the preparation of its compounds? Only a very small minority of chemists ever use such information for their work.

(ii) The balance between practical work and lectures seems to be about right. The practical side of a practical science is of the greatest importance, and nothing useful can be achieved by over-lecturing to students. What is wrong is not the amount of practical work, but its nature. The archaic system of 'spots' teaches a student little useful chemistry after the first year, and the monotony of 'spot' after 'spot,' year after year, does not encourage good practical work. The countless volumetric and gravimetric exercises are unnecessary. A student should be taught the technique of quantitative analysis from a few selected experiments. Much more of the practical work should be devoted to modern techniques, such as micromanipulation, chromatography, polarography and the like.

(iii) A method of narrowing the 'gap' would be to insist that full-time students take up a minimum amount of vacation employment with selected firms during their years of training.

ADVANTAGES OF EVENING STUDY

Mr J. H. SEAGER: With reference to the lady speaker's remarks everyone must surely agree with the Chairman that in a Conference of this sort it is understood that women chemists are included in the general term. However, from the industrialist's point of view I would say we all accept that women chemists can be just as capable as men, but in view of the risk of loss through marriage we naturally prefer the male whenever this is possible.

I wonder, in fact, whether any drastic change in the training of the chemist is necessary. Previous speakers have confirmed that the industrialist is very satisfied with the chemist he gets from the university; all he wants is more of them. However, will he be satisfied with more chemists of a narrower curriculum? There is a lot to be said for sandwich courses, but there is even more to be said for evening classes, and I would have thought that by expanding these facilities—and I understand that almost all evening colleges are filled to capacity—you would enlist far more men prepared to take their degrees this way and with no desire for the universities to relax their standards. Many hundreds of chemists have obtained their degrees by this method, and a large proportion of them seem to have found themselves in executive positions, so that training the hard way in the evening, coupled with the knocking about in the factory during the day-time, has evidently produced the right type of man for the industrialist. I would therefore like to see the universities carry on turning out men of a very high standard, but let the educational authorities give more opportunities for those who are prepared to study in the evening.

I am entirely in agreement with some earlier speakers when they suggest that the student should specialise in his own subject and not waste time on the humanities and languages. Let him be earnestly advised at the outset of his studies that if he is to reach top executive level a knowledge of these subjects will be very necessary, and if he is of the right calibre he will find a way to acquire this knowledge, without sticking to a hard and fast curriculum.

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STATISTICS, STIMULATION AND ALTERNATIVE COURSES

Mr E. H. W. SEARLE: Simple statistics and experimental design should be part of every chemist's training. Apart from their use as experimental tools and as a training in objective thinking, they widen a chemist's interest in a variety of fields. Their study can be enriched by examples from sport, health, agriculture, biology, education, economics, politics and industry, as well as from the experimental pure sciences. They teach the need for adequate experimentation, and this will become even more necessary as our science graduates enter industry after being fed on wave mechanics! And they can be linked with a more rigorous study of graphical methods and their application.

Twelve-year olds in the 'solid beta' group dislike abstract thought. To stimulate their interest in chemistry it would be better to replace the phlogiston theory by a discussion of the methods of criminal investigation. Fireworks should precede potassium chlorate; Christmas pudding could lead to a study of composition, and the importance of controlling time and temperature, and so on.

To encourage the supply of teachers of chemistry in girls' schools, there should be wide opportunities for students to proceed to a three-subject degree in which chemistry would be taken as one subject, with a free choice for the other two. Such graduates would be useful all-rounders in the junior school.

The tone of the Conference failed to show that industry recognises its own responsibility to educate assistants on a broad basis. Their interest should be stimulated by moving them around the various departments, with proper training throughout.

Students from the 'user' industries might well have an opportunity to take an alternative post-H.N.C. course of studies which concentrated on the practical advanced topics and ignored the more abstract studies. Detailed study could then be given to chosen fields, for example high polymers or metallurgy. Ancillaries would include statistics, research method, advanced laboratory technique and the elements of chemical engineering and economics. As usual, technical French and German would be taken, but supplemented by English for Chemists.

UNIVERSITY RECRUITMENT

Mr T. E. SYMES: One practical way in which each university can contribute to the improvement of the cultural education of the chemist and his training as a 'thinking' man, is to put an end to the policy of taking on more students than can be accommodated and failing a high percentage of them at the first-year examination. This contributes to the 'waste' to which so much reference has been made at this Conference. It is incredible that, after all that has been said here and elsewhere of the need to spread a warm enthusiasm for science in the schools, a university professor can speak of the 'cold blast of a first-year honours course.' If the university would restrict its recruitment to a number of students equal to the number of degrees it proposes to award and use the first-year examination as a test of its own competence rather than that of the student, eliminating the latter only when real evidence of slackness was forthcoming, it would be able to give time and would have freedom of action for a cultural approach to the subject, and standards would rise, not fall.

The demand for a four-year course, with its consequent further absorption of space and teaching facilities, makes it all the more imperative that the universities should recognise their moral responsibility to take the candidates selected for training as far as the degree.

WRITTEN COMMUNICATION

Dr L. H. CALLENDAR: This series of papers by experts in different branches in the training of chemists has interested me considerably, and I should like to make a few comments based on 35 years' experience on the industrial side.

I was particularly interested to see that Dr Booth advocated that the scientist should understand economics. It is certain that the average chemist knows little or nothing about the economics of works processes, or more particularly, of the factory or industry as a whole in which he is working. I well remember when I joined a certain concern as a chemist that the wise general manager handed me a book of the costs of the various processes and departments of the works and told

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me to start off by seeing where money could be saved. This study proved to be of great value to myself, and later on, of some value to the firm.

In the summary of the qualities required for a chemist to be successful, there is no doubt of the importance of clarity of expression, which few chemists possess, either verbally or in writing. I note also, particularly, the word co-operativeness in this list. My impression is that this can be easily overdone. This attitude of 'we won't have any unpleasantness' leads, in my opinion, to low quality work and inefficient working. While, therefore, co-operativeness in carrying out the chief's ideas is very important, combativeness in maintaining quality and going right through with the job is equally important to get a good finished product in a reasonable time. I should add to that the quality of never-tiring persistence in seeing that his results, once approved, get applied.

Nothing is better training for the chemist, and for his junior staff, than that the former should learn to lecture and talk to them about the processes, while continually making his talks interesting, by basing them on drawings and diagrams and relating each subject to the manufacturing scheme as a whole.

I do not think such talks from the staff to the technicians and laboratory assistants should deal much with chemical formulae or the stuff that is learnt in schools and colleges. It becomes most interesting and inspiring to the juniors, I have found, if the chemist occasionally deals with the history of discovery and invention. My most successful lectures aroused such enthusiasm with the boys, that they actually came up to me and asked me to give the lectures to them more frequently. This kind of lecture should give vivid word pictures of the great discoveries of chemistry and of science as a whole; enthusiasm thus aroused in the staff can make a great difference to the whole works.

The assistants in a works, coming from different previous environments, require a varied amount of education in getting on with the workpeople. In the first place, they want to be careful not to make a lot of statements which are afterwards proved to be wrong, because one unreliable individual in the laboratory may affect the opinion held about everyone in that laboratory, and consequently make it much more difficult for the chemist to introduce changes and new processes into the works.

For the Government service, I was interested to see that Sir Owen Wansbrough-Jones stated that the quality of the chemists which they engage are certainly higher than of many other types of scientist, and also that he found the university's grading pretty accurately borne out in the man's earlier career.

I would not say that this grading is generally borne out in industry. As a rule, a brilliant man academically is often extremely difficult to use in a works, because he wants to take everything too far and does not, for a long time, realise that industry continually wants temporary and partial solutions of its immediate problems, and it wants such solutions all the time, rather than the academic solutions that one aims for at the university.

I have not the experience to comment on university teaching, but I certainly find that those coming into the works who have spent some time at holiday tasks in works seem to start off on the right foot and fit in much better than those who come straight from the universities, even with the best degrees, but without experience of works. For a long time, such men are of little value.

It is difficult for purely academic new scientists coming into a works, for, rather unexpectedly, they think the knowledge acquired in their lectures at college is absolute or true, without exception; whereas to many of the generalisations of science, owing to the difficulty of deciding which one or more applies to a particular case, there seem to be innumerable exceptions which tend to trip up a young academic man; and, in the works, the technicians love to trip him up.

The distinguished contribution from Sir Eric James on school education is particularly valuable, and I especially agree with him in the belief that subjects should be taught, not in water-tight compartments, but in relationship to each other, such as Chemistry, Physics, Mathematics, Botany, Biology, Bacteriology, Anthropology and so on, and that their place in the scheme of life should be explained. It is particularly easy to carry this out in teaching chemistry, as it touches daily life at almost every point.

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RADIOISOTOPES IN INDUSTRIAL RESEARCH AND PROCESS CONTROL

By J. L. PUTMAN, M.A., F.INST.P.
Isotope Division, A.E.R.E., Harwell

This article is based on a paper delivered by the author to the Fourth International Instruments and Measurements Conference at Stockholm, 15-23 *September,* 1956, *and is published here by permission of the Organisers.*

Radioactive materials have already made their marks as tools for industrial applications and research. In this article I propose to spend very little time in dealing with the more established techniques, but to concentrate rather on developments of the last two or three years.

TRANSMISSION TYPE THICKNESS GAUGES

The widest use of radioactive techniques in process control is embodied in the range of instruments classified as radioactive thickness gauges. Of these the beta particle transmission type gauge is the most familiar[1–5], relying on the absorption of beta radiations in passing through a sheet of material from a source on one side to a detector on the other. The absorption is, of course, nearly exponential and is a function of the number of electrons per unit area of the material traversed. Since atomic number and atomic weight are nearly proportional in all the lighter elements except hydrogen, this means that the beta particle transmission gauge measures very nearly the mass per unit area of the absorber: in fact these gauges are often referred to as 'basis weight gauges.' It has been found in practice that the best results are obtained when the intensity of radiation is reduced by a factor between 2 and 10 in the absorber, and a range of beta-emitting isotopes has been selected which enables satisfactory measurements to be made of thicknesses from 1 to 1,200 mg/cm² (*see* Table I).

TABLE I
SOURCES OF BETA PARTICLES USED IN THICKNESS GAUGES

Isotope	Half-life	Maximum energy (MeV)	Approximate half-thickness mg/cm² (Al)	Approximate useful range of operation mg/cm²
^{35}S	87 days	0·167	2·0	0·5–5
^{147}Pm	2·6 years	0·23	4·5	1–12
^{204}Tl	4 years	0·77	35	10–150
^{90}Sr	20 years	0·53	17	
$+^{90}Y$	(in equilibrium)	2·2	160	50–650
^{144}Ce	280 days	0·30	7·5	
$+^{144}Pr$	(in equilibrium)	3·0 (+ γ-rays)	220	100–1000
^{106}Ru	1·0 year	0·03		
$+^{106}Rh$	(in equilibrium)	3·5 (+ γ-rays)	270	130–1200

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Of these radioisotopes, all except ^{35}S are now available as foils in which the radioactive material is sealed between thin metal sheets. This form is very convenient for most beta particle thickness gauges. Source activities are generally of the order of 10 to 20 millicuries. The thickness measured can be extended up to about 3 inches of steel by using sources of gamma rays as shown in Table II.

TABLE II

SOURCES OF GAMMA RAYS USED IN THICKNESS GAUGES

Isotope	Half-life	Main gamma ray energies (MeV)	Approximate useful range of operation for steel (cm)
^{170}Tm	129 days	0·085, 0·050	0·03–0·7
^{75}Se	127 ,,	0·40–0·067 (many γs)	0·5 –2·5
^{192}Ir	74 ,,	0·61–0·14 (many γs)	0·5 –3·5
$^{137}Cs+^{137m}Ba$*	33 years	0·66	0·7 –3·5
^{60}Co	5·23 years	1·33, 1·17	1·3 –7·5

* In this context, m denotes the metastable state.

Several firms are now producing thickness gauges of these kinds on a commercial basis. They are in use in many factories for the continuous recording (without contact) of thicknesses of paper, plastics, metal foils, linoleum and even for automatically checking the density of packing tobacco in cigarettes. Automatic control is incorporated as an optional extra, the response of the gauge being fed back through electronic servo-mechanisms to maintain production between specified limits. Tests have shown that more uniform production results from the use of this method than from manual control.

A recent application to the measurement of diameter of a hot extruded bar uses the penetration of beta particles through a small gap, between the bar and a fixed guide, as a measure of the width of the gap. This method is not particularly novel in itself but does rely on the use of a source which is uniformly active over a large area. Any difficulties which may occur in preparing such a source are smoothed out by mounting the source around the periphery of a rapidly rotating fly-wheel, so that the net effect is to simulate a very uniform source.

Other less conventional uses of gamma ray thickness gauges are for the measurement of throughput on a moving conveyor belt,[3] by continuously monitoring the basis weight, and for checking the density of fluids in enclosed pipes. The latter application shows promise of replacing the more cumbersome radioactive labelling technique for detecting the interface between different fuels in long distance pipelines.

The fact that hydrogen absorbs beta particles and gamma rays twice as effectively, weight for weight, as any other light element is also used in a device which measures the hydrogen content of liquid fuels.[6] By comparing the weighed density of the fuel with its absorption of gamma rays, the hydrogen content of the fuel can be deduced quickly.

Transmission gauges which rely on the absorption of alpha particles have also been developed.[7] One of these is capable of measuring foil

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thicknesses from 0·1 to 2 mg/cm^2, but is subject to variations of air density in the measuring gap between source and detector. Another has been developed more recently for measurements of gas density in the pressure region from 1 to 500 microns.[8] This has special advantages for some purposes in that it can be calibrated directly in terms of gas density and is little affected by temperature changes which affect the pressure.

BETA BACK-SCATTER GAUGES

Beta back-scatter gauges,[3,4] which enable the measurement of thickness when only one side of an object is accessible, have not as yet found such wide use as gauges of the transmission type.

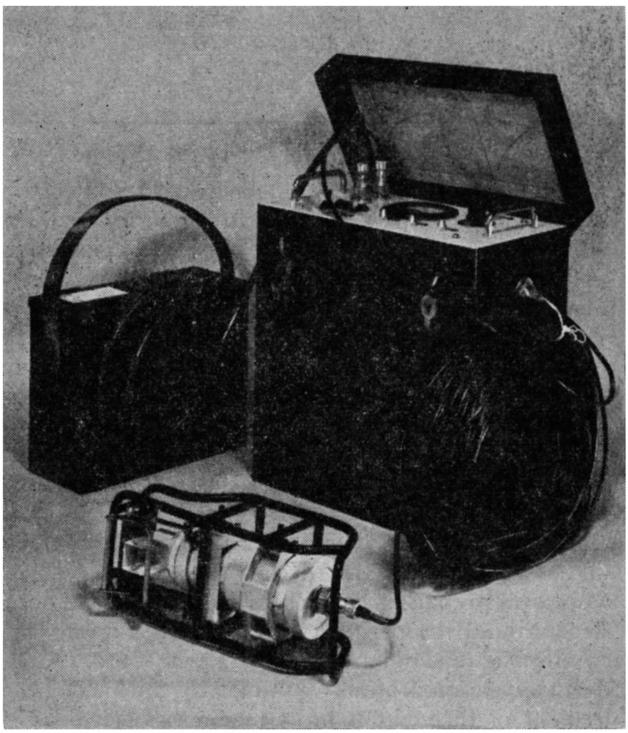

FIG. 1. Gamma ray tube-wall thickness gauge

A number of β-particle back-scatter gauges are used for specific purposes such as the measurement of metal plating or paint thickness and the monitoring of sheet rubber on a calendar roller. One important application is to the checking of silver plating on the rotor of an aircraft fuel pump. However, the diversity of shapes and conditions with which these gauges have to contend has so far precluded the development of standard commercial types.

One of the difficulties which beset this type of gauge is the fact that, unlike the transmission gauge, the position of the measured material is

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critical. The beta back-scattering gauge must be mounted at a fixed distance from the surface to be measured and where this distance is not constant, as for sharply curved objects, the interpretation of results is difficult. Some attempts have been made to limit the field of observation to a small area for problems of this kind. In a laboratory arrangement which has had limited success, a capsule of ^{85}Kr forms a collimated source of beta particles at the centre of a scintillation counter detector. Areas down to 1 cm diameter were inspected by this means, but stability was not good.

GAMMA RAY BACK-SCATTER GAUGES

The use of scintillation counters as detectors in gamma ray back-scatter gauges has opened up new possibilities in light-weight gauges of this type. By discriminating on an energy basis between back-scattered

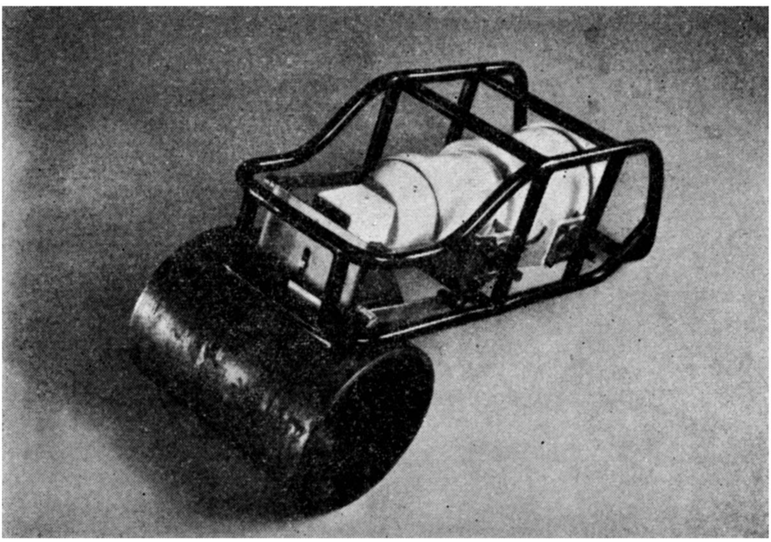

FIG. 2. Tube-wall thickness gauge. Measuring head

gamma rays and those arriving at the detector directly from the source, it has been found possible to dispense with screening between the source and the detector, and the two are mounted close together. Small sources can also be used, eliminating the need for protective screening.

A gauge built at Harwell[9] (*see* Fig. 1) to work on these principles has been in operation in an oil refinery for the last three years for monitoring the wall thickness of steel pipes and checking for local corrosion. This gauge uses 20 microcuries of ^{60}Co as a source of gamma rays and a 1-inch cube of NaI-(Tl) as phosphor of the scintillation counter, mounted 1 inch from the source. The wavelength increase of 0·0485 Å reduces the energies of the 1·17 and 1·33 MeV gamma rays, on scattering through 180°, to approximately 0·21 MeV. Thus these are easily distinguished from direct gamma rays with a single channel pulse amplitude analyser fed from the photomultiplier.

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The necessary head with its protective casing and shock-proof frame (*see* Fig. 2) weighs only 2 kg and is connected through 70 metres of cable to the transportable ground equipment.

Three British firms are developing this equipment for commercial use. It is hoped that by using a small phosphor, whose efficiency for high energy gamma rays is much lower than for the scattered low-energy radiations, the amplitude analyser circuits can be dispensed with, leaving a still simpler and cheaper instrument.

Another property of the scattering of gamma rays is being developed for the automatic sorting of coal and shale.[10] This device makes use of the fact that for gamma rays of energies near 0·1 MeV, the relative importance of Compton recoil and photoelectric absorption in gamma rays impinging on a target depends on the atomic number of the target. The probability of a recoil process increases roughly linearly with density (or rather with electrons/cm²) whereas the probability of photoelectric absorption is proportional to $Z^{4\cdot5}/E^{3\cdot5}$, where Z is the atomic number and E the energy of the gamma rays.

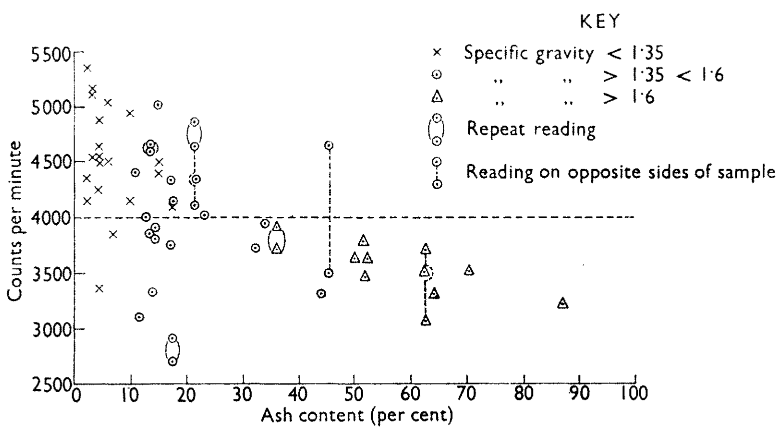

FIG. 3. Coal and shale sorting. Count rate of back-scatter gamma rays plotted against ash content

Consequently the back-scattering of low energy gamma rays from coal ($Z = 6$) is more efficient than that from shale (Average $Z = 11$ approximately), because the greater photo-electric absorption in the shale reduces the number of scattered gamma rays which can escape from deeper layers.

Laboratory experiments on 50 typical lumps of coal using ^{170}Tm as a source of 0·085 and 0·050 MeV gamma rays showed good correlation between scattered radiations and the ash content of the samples as measured later (*see* Fig. 3). The fractions separated on a basis of back-scattering contained 12 per cent and 37 per cent ash respectively.

The method is being further developed by the British National Coal Board as a possible method of automatic sorting at the pithead. It is expected that if successful, this method will compare favourably with existing methods of sorting for coals above 10 cm mesh.

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NEUTRON GAUGES

The moderation of neutrons from portable neutron sources forms the basis of a series of gauges for the estimation of hydrogen. Because its mass is close to that of the neutron, the hydrogen nucleus is by far the most efficient in reducing the energy of scattered neutrons from a fast neutron source. An equipment for field use is being developed at Harwell,[11] which consists simply of a (Po-α-Be) source of fast neutrons attached to a BF_3 counter for slow neutrons, feeding a portable ratemeter. By laying this on the ground, the total hydrogen content of the surface soil to a depth of about 4 inches can be measured in a few seconds. The hydrogen content thus indicated is also a measure of water content, provided that a small correction for organic hydrogen is made. In laboratory experiments, using such diverse materials as sand, loam and sawdust, it was possible to measure water content within $\pm 0{\cdot}01$ g/cm^3. The instrument is expected to find other applications, particularly for measurements of moisture in grain and in ceramic materials.

One limitation of the method is in the interference of soil constituents with high cross-sections for the capture of thermal neutrons. The presence of significant quantities of chlorine or of manganese, for example, can cause appreciable errors. French research workers have overcome this difficulty in an ingenious instrument which uses the radioactivation of an indium foil to detect the scattered neutrons.[12] The indium foil is screened in cadmium to absorb thermal neutrons and is thus mainly sensitive to neutrons of energies near that of the resonance peak (about $1\frac{1}{2}$ eV of indium. These epithermal neutrons are much less affected by competitive absorption in the soil.

Portable neutron sources are also used for the identification of materials through the (n, γ) reaction. The prompt gamma rays, which are emitted through this reaction when a sample is irradiated with thermal neutrons, can be analysed with a simplified scintillation spectrometer and give information about its constituents. An instrument has been built for the detection of oil-brine interfaces in oil-bearing strata[13] and has worked satisfactorily in an experimental rig in which the contents of the surrounding sandy strata were identified through 1 cm of steel and from 2 to 5 cm (variable) of cement.

TRACER INVESTIGATIONS

A number of radioactive tracer methods have now become standard practice, notably the use of short lived tracers to check the efficiency of industrial mixing processes and to measure the conditions of flow and hold-up in continuously operating industrial plant.

On a larger scale, the radioactive labelling of hydraulically operated scrapers passing along the inside of pipelines is now generally used, so that scrapers which become stuck in the pipes can be found and removed easily.[14] A hydraulic system has been devised in which the radioactive source is in a thick lead screen when attached to the scraper and emerges only when under pressure in the pipeline. This enables sources up to 1 curie or so of ^{60}Co to be used safely when detection under 3 or 4 ft of soil is required.

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Newly laid, buried water mains are routinely inspected for leakage by the use of ^{24}Na in solution as bicarbonate. Specific activities lower than drinking tolerance level are sufficient to allow detection of the radioactivity which leaks out into the surrounding soil by the use of detecting probes, and the methods are being reviewed for possible use under suitable control on mains in service. When long lengths of underground pipes are to be tested, or when they are deeply buried or otherwise inaccessible, it has been found convenient to insert a detector inside the pipe itself to find the radioactivity near a leak.

A self-contained unit has recently been developed for use in oil pipelines up to 20 miles (English miles!) long.[16] This consists of a sealed case, propelled by hydraulic pressure and containing battery operated gamma ray counters and a wire recorder (*see* Fig. 4). Pulses from the

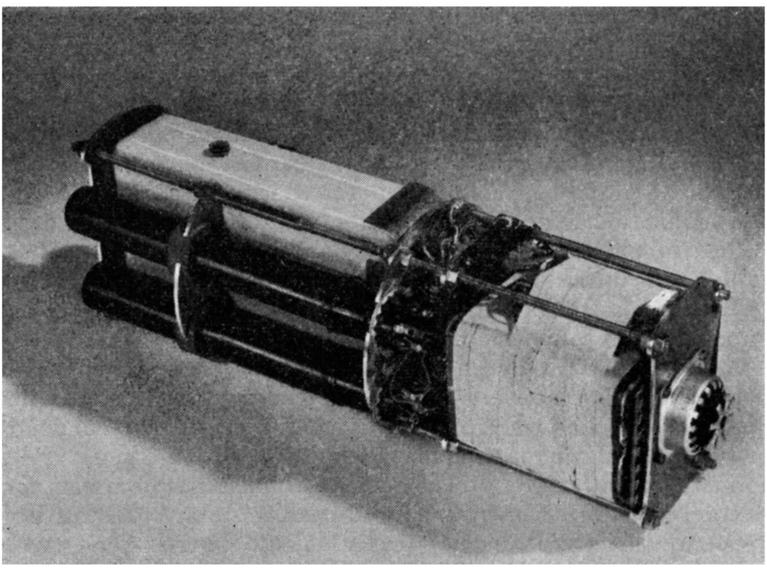

FIG. 4. Water leak detection. Battery operated unit for recording leaks in long pipe lines. Outer casing removed

Geiger counters are fed to the wire recorder, which, on extraction at the far end of the pipeline, can be played back to give a continuous record of leaks along the whole pipeline (*see* Fig. 5). It is intended, by suitable adjustment of the recording speed, to extend the use of this unit to 100 miles of pipeline.

Soluble radioactive tracers have also been applied to tracing the fate of aircraft fuel spilled in flight. In some aircraft in particular flight conditions, there is the possibility that fuel, escaping through the overflow or pressure equalising tube of a fuel tank, may reach other parts of the aircraft. It is essential to ensure that such fuel cannot reach hot parts of the engine where it might cause a fire. The short-lived beta emitter ^{109}Pd is introduced during refuelling in the fuel-soluble form of the

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acetyl acetonate or diethyldithiocarbamate. In flight, this is deposited by any spilt fuel even if the fuel evaporates away. An inspection with a beta counter after the test flight reveals all places where spilt fuel has been.

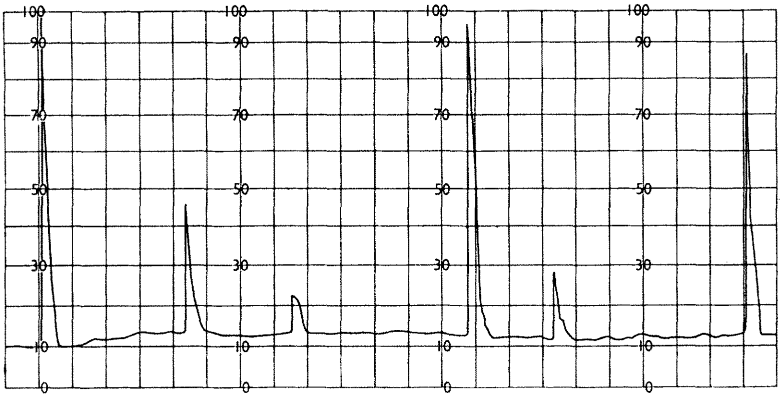

FIG. 5. Water leak detection. Typical chart obtained on play-back of recorder (large peaks are distance markers: 200 μc of ^{60}Co placed outside the pipe-line: smaller peaks correspond to leaks)

WEAR TESTING

Research by the Shell Oil Company[17] using test engines with radioactive piston rings has yielded much information about the wear of engines under various running conditions. Wear debris, suspended in the circulating lubricating oil, is monitored with a Geiger counter immersed in the circulating oil stream, and the counting rate obtained gives a continuous indication proportional to total wear without dismantling the engine. These investigations have already resulted in the development of improved lubricating oils and additives. It has been found by similar researches that the wear rate in a motor-car increases sharply when the speed increases to between 55 and 70 miles per hour, a fact which, if given wide publicity, may prove to have as much effect on the life of the community as on that of the car.

Following pioneer work in Sweden and America,[18,19] another British firm has set up a laboratory for the wear testing of cutting tools.[20] The tips, made of tungsten carbide in a cobalt matrix, are irradiated separately in a reactor to avoid making the whole tool radioactive. Their mass has been reduced by careful design to about 1 gram, which enables high specific activity to be used without danger, thus permitting high sensitivity in measurement of the wear debris.

AUTORADIOGRAPHY

The use of photographic techniques for the measurement of radioactive distributions is playing an increasing part in the study of metals and alloys.[21,22,23] For research, their most fruitful use is in investigations of alloy structure and of diffusion on a microscopic scale. Depending on

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the radioisotope used and the energy of its beta radiations, resolutions down to 1 or 2 microns are obtainable with very thin samples, if fine grain stripping emulsion is used in intimate contact with the source.

In practice, when the radioactive sample is a piece of metal of finite thickness, such as an alloy sample made up with one constituent radioactive, the radiations arise from layers inside the surface of the sample, and resolution suffers. For practical purposes in such a sample the resolution is roughly equivalent to the mean depth of penetration of radiations in the sample (650 microns for ^{56}Mn beta particles in aluminium, to quote a particularly unfavourable example). In such events and when high resolution is essential, it becomes necessary to grind and polish the sample down to a thickness comparable with the resolution required.[22] Several methods have been evolved with varying success. The sample is mounted first on a holder which will not become radioactive in the pile (*e.g.* polythene or polystyrene) or whose activity can be allowed to decay away (*e.g.* aluminium). It is ground as thin as practicable and polished, then cleaned and irradiated with its holder in the pile. A thin impervious coating (*e.g.* a collodion film) is generally applied to separate the sample from the radiographic film, so as to avoid spurious chemical artefacts.

Surface activation can sometimes be produced on a specimen by immersing it in a solution of a radioactive substance which is selectively adsorbed or chemisorbed to the surface.[24] When this is possible very good resolution can be obtained, but there may be difficulty in interpreting the autoradiograph. For example, we have used the immersion of tin-plated iron in cobalt chloride solution, containing ^{60}Co, to obtain autoradiographs of imperfect plating, through the selective deposition of cobalt on the exposed iron.

In other fields of industrial research also autoradiography has produced useful results. The labelling of a few selected wool fibres with ^{32}P has enabled their passage and orientation in the carding process to be studied.[25] Wool fibres treated with ^{131}I also selectively absorb the iodine by reaction with the tyrosine fraction of the protein, and autoradiography is then used to study its distribution.

An example of unexpected information being provided by autoradiography occurred in recent tracer experiments in the paper-making industry.[26] A formaldehyde resin, labelled with ^{35}S, was being used for measurements of resin retention during the manufacture of paper. Geiger counter measurements showed that the concentration of resin on one side of a paper sheet was greater than that on the other, and autoradiographs were taken of both sides of the sheet to examine the distribution. Inspection of the autoradiograph on the more active side of the sheet (*see* Fig. 6) showed that the resin distribution was patchy, and the resolution was good enough for separate fibres of the paper to be distinguished microscopically. Its interpretation enabled the mechanism of migration of resin from one side of the sheet to the other during laboratory drying to be deduced, a phenomenon which had not been suspected previously.

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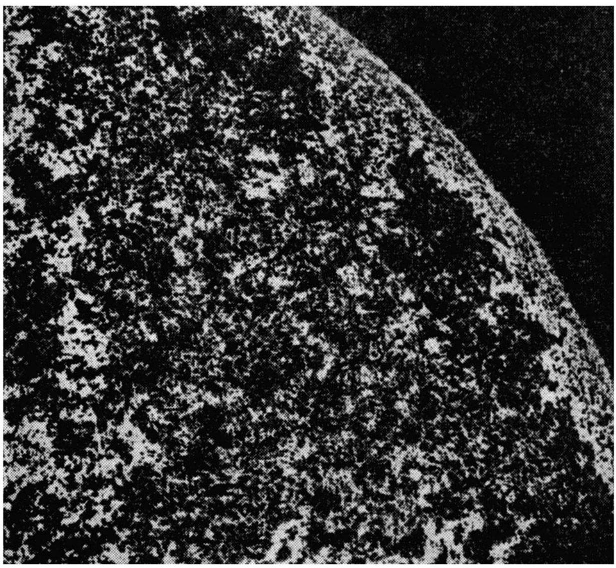
Some useful applications of the technique have also been made on a macroscopic scale. In the continuous casting of aluminium, the design of the cooling system as related to the speed of casting is critical in determining the quality of the cast ingot. Knowledge of the isotherms in the moving, cooling billet of cast metal is essential, and in particular it is necessary to know the shape of the solidifying bed of a molten pool of aluminium at the top of the billet. The addition of radioactive gold (^{198}Au) to the input stream of aluminium enabled the bed to be labelled radioactively as it cooled. An autoradiograph of a section of the solidified



(*By courtesy of T.A.P.P.I.*[26])

FIG. 6. Autoradiograph of ^{35}S-labelled resin in paper manufacture

billet then showed clearly the solidfication boundary and also gave information about the flow of aluminium within the molten pool. The mass of gold needed was only 1 part per million of the mass of molten aluminium in the pool, so that the addition did not significantly affect its metallurgical properties. It is interesting to note that in the first tests[27] (with 7 parts per million of gold), the radioactivity was introduced after the addition of the tracer, by irradiating the polished section in a reactor, thus avoiding the use of radioactive materials in the production process.

Tests similar in principle, in which the conditions of solidification in the casting of steel were investigated, have since been described by Samarin[28] at last year's Atomic Energy Conference at Geneva.

RADIOACTIVATION ANALYSIS

Considerable progress has been made in both chemical and physical techniques related to radioactivation analysis.

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On the physical side great advantages have been gained by the use of scintillation counters as detectors. A simple single-channel pulse amplitude analyser enables a plot of gamma ray energies to be made from an irradiated sample, from which various impurities can be distinguished on an energy basis.

We have been using an analyser of this kind for some time coupled to a recording milliammeter. The paper movement in the recorder is geared to a potentiometer, which sets the bias of the amplitude analyser. The milliammeter registers the counting rate obtained. Thus a 'differential bias curve' of the scintillation counter is plotted automatically in 15 minutes or longer, as required. The system is arranged to repeat itself indefinitely and can thus be left running overnight. This is particularly convenient for the analysis of samples whose radioactive constituents have half lives of a few hours, because the comparison of successive plots allows the identification of isotopes by decay rate as well as energy of their radiations. Further, the purity of this exponential decay is a confirmation of the accuracy of corrections applied in analysing the energy curve. Using this analyser we have measured copper and manganese as impurities in repurified aluminium at levels of 1 part in 10^6 or 10^7 respectively without chemical separation.

One of the difficulties in making such an analysis lies in the elimination of pulses arising from Compton recoil events in the phosphor of the scintillation counter. For example, if ^{24}Na is present in the sample, not only are 'photoelectric peaks' obtained corresponding to the complete absorption of 1·4 and 2·8 MeV gamma rays, but there is also a broad spectrum of pulses at lower energies which partly mask the peaks obtained from lower energy γ-rays.

Instruments have been built which eliminate the Compton recoil pulses by anti-coincidence.[29] In these the detector crystal is surrounded by another phosphor which responds to any γ-rays scattered out of the main detector. Thus, by an anti-coincidence arrangement, only those γ-rays which are completely absorbed in the detector crystal without scattering are recorded. Unfortunately such instruments are complex and expensive.

For this reason a method has been devised at Harwell in which the simple subtraction of two counting rates is used to eliminate the scattered radiations.[30] Two scintillation counters, using respectively NaI-(Tl) and anthracene as phosphors are exposed to the source simultaneously. Their outputs are applied in rapid succession to a ratemeter in such a way that the counting rates are subtracted. Now the anthracene phosphor, consisting entirely of elements of low atomic number, produces very few photoelectric pulses and can thus be used as a compensator to reduce the effect of Compton recoil.

This subtraction principle, although it slightly increases the statistical fluctuations obtained, is capable of wide application. It is also being used in the analysis of radioactive materials in the presence of other, known species. This is done simply by the subtraction of responses of two identical scintillation counters, one counting the mixture and the other a preparation of the known contaminant.

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SOME UNUSUAL TRACER TECHNIQUES

I shall conclude with an account of some unorthodox methods which we have used when radioactive concentrations have been low, as a result of heavy dilution.

In an investigation of the retention of calcium in cast iron, 0·05 per cent of metallic calcium, containing 1·7 mc of ^{45}Ca per gram, was added to a 35 kg melt.

Measurements were to be made on ingots 2·7 inches in diameter by about 2 inches high. Owing to the small concentration to be measured (5·7 parts per million) and the low penetration of the 0·25 MeV beta particles, the beta particle count rate at an exposed surface was much too low to measure. Instead we were able to obtain a total counting rate equal to about twice the background by measuring the *bremsstrahlung* (secondary electromagnetic radiations) generated in the samples.

A pile of steel discs was then prepared which had the same height as the samples, and a thin ^{45}Ca source of measured activity was spread uniformly between two thin steel discs of the same diameter. A series of measurements was made, showing the *bremsstrahlung* obtained when this source was in various positions in the synthetic pile. The results were integrated to obtain the counting rate to be expected from a known, uniformly distributed sample. By comparing this rate with the counting rate obtained from the unknown samples, their ^{45}Ca content was determined and hence their calcium content was established.

In some other work where heavy dilutions were occurring we have used bacterial tracers as an alternative to radioactivity.[31,32] In a recent experiment both ^{32}P (11 curies) and the red-staining bacterium *Serratia marcescens* (10^{12} cells per hour) were used to label sewage effluent discharged under the sea.

The bacterial tracer was found to be at least as sensitive an indicator of flow as the radioactive one. Unfortunately a period of a few days was needed to culture the bacterial samples, whereas radioactive measurements were taken on the spot. The methods are being considered for use together in subsequent investigations.

CONCLUSION

In this brief review of developments I have purposely confined myself to tracer techniques and those which rely on the absorption and scattering of radiations from relatively small sources. The exciting new advances which are being made by the use of massive doses of radiation from large sources are another story.

Radioactive techniques of the kind we have been considering are moving into a new phase. In industrial control, a few well tried techniques are now accepted as standard practice. Radioactive thickness gauges in particular are commercially available equipments, whose principles are well established. Their further development is taking place rather along engineering lines than by modification of any of their physical principles.

In the laboratory, the cream has been skimmed off those applications where the mere use of radioactive techniques can bring spectacular

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advances. After the first flush of successes which attends the introduction of a new technique, radioisotope methods are falling into their proper role as routine tools of the modern scientist.

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RADIO-TRACERS IN THE INDUSTRIAL CHEMICAL FIELD

By G. B. COOK, B.SC., PH.D.
Isotope Division, A.E.R.E., Harwell

In the preceding paper a number of industrial uses of radioisotopes that have led to the development of instruments for process control are described. Many of these are used also in the chemical industry, but it is the purpose of this article to describe certain other approaches that have

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been found useful. The usual approach in many, and particularly in chemical, problems requires that the radioisotope be introduced directly into the system at some stage, and thus it may find its way into the product—usually an unacceptable condition of use. This has prevented a widespread use of radioisotopes in connection with many problems of production, even though only very small amounts are likely to reach the final stages. It explains why methods using devices that do not admit radioactivity to the product have developed much more rapidly than others.

Experiments are generally performed first on a laboratory or pilot-plant scale, and the experience thus gained is then used in production but without the use of active material. In some of the examples given below, full or pilot-plant results have not been obtained, and in referring to them for purposes of illustration, I have restricted myself to laboratory experience of problems of immediate industrial importance. Since analytical chemistry is of fundamental importance to all chemical work, it is convenient to consider this first, particularly as many new techniques have been developed.

ANALYTICAL USES

The most fundamental technique that has been developed is radio-activation analysis, used widely for the estimation of traces of certain elements in *e.g.* transistor materials and zone-refined metals. The method involves bombardment of the sample, usually with slow neutrons, followed by chemical separation of the impurity (with addition of 'carrier' after activation) and by comparison of the radioactivities induced in the impurity and in a known amount of that element bombarded at the same time as the sample. Many elements have been determined in this way. As a number of excellent reviews have appeared on the subject, no further reference to the standard method will be made, except to mention that there are several valuable papers in which such important points as sensitivity (compared with other methods), limitations and sources of error are discussed.[1–4]

The half-life of the radioisotope of the element present as impurity has a direct practical bearing on the problem; it must be sufficiently long to permit measurement of the radioactivity after chemical separation and purification have been completed. By selection of an appropriate chemical method, it is possible[5] to measure thorium in complicated mixtures by formation of ^{233}Th, which has a half-life of only 23 minutes. In suitable instances, chemical separation may be possible with radio-isotopes of shorter half-life, but there is a limit beyond which no separation can be made, and several elements whose isotopes have a half-life of less than a minute have been determined without chemical separation. The work has to be done at the reactor and with a means of fast removal of the sample from the pile, but the lack of chemical separation leads to some uncertainty, and the identification of the radioactive species must be made from half-life alone (unless γ-ray emission allows an additional check by its energy). Levêque and Goenvec[6] have determined fluorine (but not in trace amounts) from the induced activity of ^{20}F (half-life 12

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seconds) in various phosphates, and trifluorochloropolyethylene and also hafnium (^{181m}Hf; half-life 19 seconds) in zirconium. It is fortunate in these examples that although ^{19}O (formed from stable ^{18}O) and ^{16}N (from ^{15}N) have half-lives of 29 seconds and 7 seconds respectively, the abundances and cross-sections of the relevant isotopes are very low.

Analysis of oxygen itself has been attempted by following up an ingenious idea.[7] Lithium, on capturing a neutron, disintegrates into an α-particle and a triton ($^3_1$H). The latter has about 2·7 MeV of kinetic energy and can cause further reactions. On collision with ^{16}O, it reacts and loses a neutron to form ^{18}F (half-life 119 minutes), which is used to determine the oxygen content. Osmond and Smales[7] have used this method for the determination of oxygen in beryllium by mixing the finely divided sample with an excess of an oxygen-free lithium salt; the sensitivity, however, was not high (0·1 per cent), and very finely divided samples are necessary, as the range of the triton in matter is very small. In principle, the method could be used to determine lithium, and also magnesium, by the formation of ^{28}Mg, which has a half-life of 21 hours (as against the 10 minutes of ^{27}Mg, which is formed directly by neutron capture). In this case the reaction is ^{26}Mg (t,p) ^{28}Mg.

The idea of non-destructive analysis is very attractive to the chemist, and some success has been achieved with the development of the γ-scintillation spectrometer, which readily determines the energy of the characteristic γ-rays of the γ-emitting isotopes (*see* previous paper). Trace amounts of several elements have been detected and determined in various samples without chemical separation,[1,8,9,10] and further advances on these lines are to be expected, coupled with developments in instrumentation. The method must, of course, be used with discretion, as the activity of other constituents of the sample may hide the effects of micro-components, and γ-ray energy is not a unique criterion of identity.

The discussion so far has been confined to samples bombarded in a normal thermal reactor, but one of the earliest examples of activation analysis made use of deuteron bombardment.[11] The method has been used only infrequently since then because of the limited cross-sectional area of the beam of charged particles, the difficulties of obtaining uniform bombardment of samples, and the limited penetration of the charged particles in solids. This last effect is to some extent overcome by the use of energetic and penetrating γ-rays from a betatron. However, carbon (0·06-1·0 per cent) has been determined in steel[12] and in organic compounds[13] by the reaction ^{12}C (d,n) ^{13}N, the nitrogen produced having a half-life of 9·9 minutes, which is sufficiently long to allow of a ready determination. It is doubtful, however, whether much was gained over the conventional methods. Oxygen has been determined by the ^{16}O (γ,n) ^{15}O reaction, measuring the positron activity of ^{15}O (half-life 2·1 minutes) in organic compounds and in aluminium metal.[14] A betatron (22 MeV) was used as the source of γ-rays in the determination of oxygen down to 0·2–0·3 per cent in 2–3 g samples of organic material and 0·1 per cent in aluminium. The authors thought it possible to extend the method to carbon (^{11}C; half-life 20 minutes) and nitrogen (^{13}N). Such methods depend on access to the appropriate machines, which are not

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readily available as yet; their use in analysis is therefore likely to be restricted to special purposes.

The use of small laboratory neutron sources has also been frequently suggested,[15] but the neutron emission is so low that they are useful only for analyses of major components and then only for those elements of high neutron activation cross-sections. The use of laboratory neutron sources with a neutron emission 100 times that of a standard 1 curie radium-beryllium source would naturally change the situation both analytically and industrially (*see* ref. 1, p. 104).

In principle, radioactivation analysis can be applied under favourable circumstances to all elements, with the possible exception of hydrogen. Beryllium, boron, carbon and oxygen require other means of activation than neutrons, and aluminium, fluorine, neon, niobium, rhodium, titanium and vanadium yield only short-lived radio-isotopes, so that they cannot often be determined by these means. The naturally occurring radioactive elements of long half-life, such as uranium and thorium, can be determined normally, but the radiations from materials of shorter half-life, such as radium, are readily detected without neutron irradiation. Thus, it can be readily appreciated that the use of activation analysis in industry is as wide as analysis itself.

BACK-SCATTER METHODS

The use of beta back-scatter gauges for determining the thickness of a coating of one substance on another has already been mentioned. The amount of back-scatter for a given geometrical arrangement and radioactive source depends on the thickness of the scatterer and its average atomic number. Beyond a certain thickness of a given material, the amount of back-scatter is constant (saturation back-scattering), so that in this region the back-scatter can be used to determine the average atomic number, which for a system of known components amounts to an analysis. This method has been used by Russian workers for the rapid determination of the composition of chromium-niobium and iron-tungsten alloys.[16] A linear relationship between the intensity of the back-scattered radiation and the percentage of niobium in the chromium-niobium alloy was found. An accuracy of $\pm$ 2 per cent was claimed for a niobium content of more than 3 per cent.

Attention has also been paid to back-scatter from aqueous solutions[17] where a similar linear relationship between the extent of back-scatter and solute concentration was found. Although it is unlikely that these methods will have a general application, their simplicity and speed might on occasion prove advantageous.

ISOTOPIC DILUTION

The isotopic dilution method of analysis was first developed with enriched stable isotopes and by determining the changes in enrichment by means of mass spectrography. The method can be equally well applied with radioactive isotopes and normal means for the determination of ionising particles. Although the method is elegant and powerful, it seems to have found little favour in general analytical practice. This

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is perhaps not surprising in inorganic work, but a few examples, such as the determination of traces of sulphate in plating baths,[18] the anodic deposition of cobalt[19] and the determination of small quantities of rubidium in carnallite,[20] have been published.

It is in organic and biochemical analysis that the method and its developments, the reverse isotope dilution and the derivative dilution methods, would appear to be most useful.[21] In all variations of the method, the substance to be analysed must be separated in a chemically pure condition, but not quantitatively, a condition often fulfilled by chromatographic methods in their various forms. Some recent examples of the use of this technique are in the analysis of vitamin B_{12} (a cobalt-containing compound),[22] hydroxy and amino-compounds,[23] some dichlorodiphenyl polychloroethane compounds[24] and the γ-isomers of hexachlorobenzene.[25,26] This last example is interesting, as the results were so satisfactory that it was suggested as an official referee method.

In derivative dilution methods, a derivative of the compound must be formed quantitatively with a radioactive reagent of known specific activity, and the derivative is then freed from excess reagent and purified after the addition of a known quantity of the inactive derivative to act as carrier. From the known recovery of the carrier and the known specific activity per mole of the radioactive reagent, the content of the required species in the sample is readily obtained. Examples of this method of analysis are the determination of γ-aminobutyric acid in brain matter,[27] of pyrimidines in hydrolysates of nucleic acids,[28] and of carboxylic acids, acid chlorides and anhydrides.[29]

Perhaps the chief disadvantage of the simple isotope dilution technique is the requirement that a quantity of the pure material must be isolated and this quantity determined by normal chemical means (weighing, colorimetric analysis and so on), which often means that fairly large samples must be available. The derivative method can be easily applied to microgram quantities, but it necessitates complete, or at least reproducible, reaction with the radioactive reagent. Using the reverse dilution technique, a radioactive drug, say, of known specific activity is fed to an animal and subsequently recovered from the tissue by the addition of a known amount of inactive compound, which enables normal purifications to be performed. The content of drug in the sample is obtained simply, because the β-count per mg is already known. This method can be very sensitive, depending on the specific activity of the original compound.

OTHER ANALYTICAL USES

The radioisotope technique can be a considerable aid in following the behaviour in a complicated system (both inorganic and organic[30]) of a particular radioactive component (*see*, for example, ref. 20). It may provide information as to the extent of co-precipitation, solvent extraction and the like, particularly on the semi-micro and micro-scales, and is helpful in determining low solubilities.

The use of radioactive reagents for volumetric analysis was tried out some years ago, and they have recently been applied to water analysis for

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chloride and sulphate.[31] The method does not appear to be widely used, but it may offer some advantage when determination of the end-point is difficult by ordinary visual means. The principle involved is the removal of the radioactive reagent from solution by forming a precipitate; the end-point is reached when the radioactive content of the solution rises.

The determination of hydrogen in hydrocarbons by β-particle and γ-ray absorption methods has been mentioned in the previous paper. A similar technique has been used for the determination of sulphur (in any state of combination) in hydrocarbon oils.[32] Sulphur atoms absorb X-rays of about 6 keV energy about 20 times as efficiently as those of carbon and more than 400 times those of hydrogen. Consequently the absorption of X-rays of this energy in such solutions is largely dependent on the sulphur content. As a stable source of X-rays of suitable energy, it is convenient to use ^{55}Fe (about 4 mc), a K-capture isotope that emits only Mn X-rays with a half-life of 2·9 years. The apparatus consists of a source of ^{55}Fe, a thin absorption cell to hold the sample, a detector such as a Geiger counter and the necessary electronic gear. The method is rapid and has been used for sulphur contents of 0·05–3 per cent; it could possibly be used for a few elements of atomic number close to sulphur's in a similar matrix, but elements of higher atomic number must either be absent or an allowance made for their presence.

A final example from analytical practice is one of control in the steel industry,[33] where rapid analyses of slag and metal are necessary to follow the progress of a melt. In the open-hearth smelting of 'high phosphorus' cast-iron, it has been found possible to determine the phosphorus content of the slag with sufficient rapidity and accuracy by introducing radioactive ^{32}P into the melt to the extent of about 0·05 mc per ton of cast-iron. The slag could be analysed for phosphorus content by the β-activity of the ^{32}P in 5–7 minutes, with an error not exceeding 6 per cent. The activity also facilitated the sorting of the slag for subsequent use as a fertiliser. The same method has been applied to calcium determination, using ^{45}Ca as a control of slag basicity.[34]

CATALYSIS

Separated stable isotopes have been employed in research on catalysis for many years, and it is natural that the technique should have been extended to the radioactive species. The formation of higher hydrocarbons from carbon monoxide and hydrogen by the Fischer-Tropsch synthesis has been studied extensively. It was shown[35] that the hydrocarbon products contained very little radioactive carbon when a catalyst was used in which ^{14}C was incorporated as the carbide. This indicated that the carbide took no direct part in the reaction. When labelled alcohols were added,[36] however, the hydrocarbons produced had a specific activity of about one-third to one-half that of the alcohol used. This was taken as evidence that the alcohol molecules acted as nuclei for the formation of higher alcohols. Fletcher and Gibson[37] have also obtained radioactive products on using radioactive carbon monoxide in the feed.

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An important factor in such work is catalyst poisoning. Bokhoven[38] has suggested that the poisoning of catalysts by carbon dioxide and carbon monoxide in the ammonia synthesis is related to the water produced in the reduction of these gases to methane and not to adsorption of these gases on the surface of the catalyst. In this enquiry a tracer was used essentially as an analytical tool to determine readily the CO and CO_2 concentrations in the gas streams. True tracer methods have been used in studies of the coking of catalysts in hydrocarbon conversions.

Coke formed from the cracking of *n*-heptane labelled on the middle carbon position and from *n*-octane and octene,[39] labelled on the terminal carbon position, was found to have the same specific activity within the limits of experimental error, showing that all carbon atoms are equivalent in this process. On the other hand, the specific activity of coke deposited on silica–alumina catalysts during the transfer of hydrogen from naphthenes to olefins (using ^{14}C butene) showed that the naphthenes yield much coke; other similar experiments demonstrated that tetralin deposits coke more readily than does decalin.[40]

On a larger scale, the conversion of naphthenes to aromatics over molybdenum oxide–alumina catalysts has been studied on pilot-plant scale. Methyl*cyclo*hexane, labelled with ^{14}C in the methyl position, was added to the feed, which consisted largely of methyl*cyclo*hexane, dimethyl*cyclo*-pentane and *n*-heptane, and the distribution of ^{14}C in the products was examined.[41] Radioactive carbon was found largely in the toluene and xylene fraction, but also in the coke, light paraffin gases, other paraffins, naphthenes and aromatics. Activity was also found in benzene and the benzene ring of toluene, showing that some isomerisation had occurred.

A full-scale plant investigation[42] was made to ascertain the whereabouts of the platinum that in the course of time is removed from the catalysts used in the manufacture of nitric acid by the catalytic oxidation of synthetic ammonia. The catalyst was activated by neutron bombardment and inserted in the plant. In the first instance, the platinum was located and analysed by its radioactivity, and, after removal of the radioactive catalyst and the insertion of an inactive one, the fate of the old radioactive deposits was ascertained as inactive deposits accumulated.

A useful control method under full operating conditions has been developed for catalytic crackers employing circulating catalyst beads.[43] In this process the incoming gas carries catalyst beads through a reactive zone where 'cracking' occurs. The 'cracked' gas then flows out of the plant but deposits the catalyst, which then flows through a furnace to burn off any coke deposited on it in the cracking process, and is then returned to the system. The flow rate of the catalyst, which is difficult to determine, is an important operating characteristic. By using a few beads each impregnated with a small amount of a γ-active, non-volatile isotope (^{95}Zr), the flow rate can be determined by the time taken for the tagged bead to travel between two rings of counters fixed some distance apart around the pipe leading to the furnace. The counters detect, on the outside, the penetrating γ-radiation as the bead passes each ring of counters, and the flow rate can be calculated from the measured time and the known capacity of the leg between the two rings of counters. Although

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the control is not, strictly speaking, continuous, a measurement is made sufficiently frequently for adequate control.

SMALL MASS TRANSFER STUDIES

The ease with which minute traces of radioactive material can be detected is of great value in experiments where very small traces are transferred from one medium to another. It permits such transfers to be measured much more rapidly than do standard techniques. This has proved of great importance in the determination of tool wear and in engine studies, where it promises to become a standard method for the evaluation of wear and the effects of oils and oil additives on it. The great advantage of the tracer technique is that accurate information is obtained very much more rapidly than by previous methods. The technique is not only applicable to engineering problems. The study of the wear of tyres[44] was greatly improved by the incorporation of a plasticiser, triphenyl phosphate, labelled with radioactive ^{32}P, into the tread of tyres. The mass transfer was determined by the amount of radioactive material transferred to the road surface. The wear was measured in short distances as a function of speed and acceleration, instead of running the tyre for several thousand miles, with a wide variety of conditions contributing to the effects. These tests, showed, for example, that the life expectancy of a tyre at 60 miles per hour was only 57 per cent of its value at 30 m.p.h.

The rate of wear of moulds in the plastics industry has been investigated by similar methods,[45] and traffic paint abrasion has been studied by determining the thickness of the paint layer periodically, and very simply, with a beta back-scattering gauge.[46]

In a study of aircraft de-icing,[47] a labelled silicone lubricant was applied to the rubber de-icing tubes for aircraft wings. It was shown that the silicone layer splits as ice is torn from the rubber surface, and a small amount of silicone, detected by its radioactivity, was measured on the ice. A similar study has been made of metal transfer in the operation of contact-breakers.[48]

STEEL AND STEEL MAKING

Radioisotopes have been extensively used in metallurgy since they became readily available. Self-diffusion, segregation of alloys and the effect of treatment on it, inclusions, and the distribution of elements such as phosphorus and sulphur between slag and metal have all been studied extensively, and this is by no means an exhaustive list.

An interesting experiment on blast furnace behaviour was reported recently.[49] A very finely divided iron ore was concentrated from some low-grade deposits. If this ore, mixed with coarse material, were fed into a blast furnace, there was a good chance that the fine material would be blown out by the air of high velocity normally used. Five pounds of the ore were irradiated to form the radioactive isotopes, and this was well mixed with 22 tons of identical but unirradiated material and 54 tons of a coarser ore. On feeding the mixture to the blast furnace, pig iron was formed, and from the radioactivity of the pig iron, the slag and

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the airborne dust, it was found that 60 per cent of the fine ore had emerged as pig iron. Although surprisingly high, this figure was not considered practical.

In open hearth furnaces, the extent to which sulphur dioxide from the fuel (oil or gas) contaminated the furnace charge was found by adding ^{35}S to the fuel and examining the metal, slag and gas for radioactive content[34] after various periods of heating. The metal was found to contain 10–20 per cent of the sulphur present in the furnace gases during melting whilst at the same time, and to a lesser extent, sulphur from the metallic charge escaped to the gas phase. In the refining period, only 1 per cent of the sulphur from the fuel contaminated the metal. The sulphur content of the metal could be reduced by enriching the air feed with oxygen during the melting period, because the time of fusion was reduced. Another very simple investigation of an open hearth furnace[34] showed that the time of melting and mixing of a 20 kg piece of ferrochromium (made radioactive) in a 190-ton furnace was 10–20 minutes, this being the time required for the radioactive content of the melt to reach a steady state.

Typical tracer experiments have been performed to find the origin of non-metallic inclusions in ball-bearing steel on the production scale,[34] with radioactive ^{45}Ca incorporated into slags and the linings of furnaces and ladles. The slag produced in the reduction period of the heating of an arc furnace with acid or basic linings was not the source of contamination either in melting or in the simultaneous tapping of steel and slag into the ladle. When bottom pouring was employed, about 9 per cent of the inclusions arose from the destruction of the refractory lining, whereas the erosion of the ladle brick contributed up to 18 per cent. This could be reduced to less than a half by the use of a high alumina brick lining instead of the type previously used.

DISTILLATION PROCESSES

The sensitivity attainable with radioisotopes has been used to advantage in the determination of low vapour pressures, such as those of refractory metals and alloys. The method may be applied by determining the mass of vapour in a fixed volume or by an effusion technique, whereby the saturated vapour contained in a gas stream is condensed in a cold trap and the mass measured from the known radioactive content. Recent examples are the determination of the vapour pressure of bismuth[50] and that of phosphorus in an iron-phosphorus alloy[34] at high temperatures. Several techniques for the continuous analysis of vapour concentration under atmospheric and higher pressures[51] have been described in studies of gaseous diffusion; they have the advantage that the system is not disturbed by the withdrawal of samples. Such methods can be used for the determination of the partial pressure of one component of a multi-component system, as in the continuous determination of the partial pressure of H_2S by means of ^{35}S in a gas phase consisting of CO_2, H_2O and H_2S.[52]

An interesting practical example was an investigation[53] into the malfunctioning of a heavy oil vacuum distillation column in an oil refinery.

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The column had 14 plates, each of which had 8 bubble caps set in its own portioned-off section of the plate. It was found that heavy metals were contaminating the volatile fractions, and it was suspected that there was a bad distribution of the down-flowing scrubbing liquors in the trays, so that some bubble caps were not covered and entrained involatile material was passing up the column unwashed. In an attempt to determine whether there was a poor distribution of scrubbing liquor, it was labelled with 10 mc of radioactive triphenyl antimony, a non-volatile, oil-soluble compound. The distribution of activity in the trays was determined by placing detectors outside the column on a level with a suitable plate and with a detector for each bubble cap position. The response of the detectors showed that the activity was concentrated on one side of the tray, with very little on the other side. The poor distribution of the scrubbing liquor was confirmed when the column was dismantled. Additional information was also obtained on recirculation times from the same data.

In another example,[54] the amount of tar entrainment in a distillation unit was determined. Tar could not be tolerated in the volatile products, because they were fed to a catalytic cracking unit. A full plant-scale test was made to learn where entrainment occurred, so that the design could be modified to make the plant work at maximum output. A small quantity of a non-volatile, oil-soluble, thermally stable barium compound labelled with the radioactive ^{140}Ba (half-life 12·8 days) was prepared and added to the still (at various points in different experiments), which was operated under the desired conditions. Examination of distillate and residue for radioactive content showed what proportion of involatile matter was carried over to the distillate. It varied in amount up to about 5 per cent.

CONCLUSION

It can be seen that a wide variety of problems have been studied by radioactive tracer techniques, and the examples given by no means exhaust the list even on the subjects specifically included. No mention has been made of applications to such processes as vulcanisation, polymerisation, corrosion, absorption, ion exchange, surface conditions and cleaning, detergency, many oil refinery techniques, and many metallurgical operations, to say nothing of the wide use of isotopes in the biochemical and agricultural industries. Many more problems of a similar nature to those discussed probably exist and could be solved by taking advantage of, and possibly extending, methods that are already known. New techniques, such as the use of the neutron industrially, are interesting possibilities for the present and future.

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BOOK REVIEWS

Breads White and Brown. R. A. McCance and E. M. Widdowson. Pp. xi + 174. (London: Pitman Medical Publishing Co., Ltd., 1956.) 30s. net.

This book is outstanding and is one most workers in the field of nutrition will want to read and re-read. The major portion of the book is a fascinating historical account of various breads and their place in thought and social history. Indeed, out of the nine chapters, the first seven give a critical survey of bread throughout the ages. This makes most interesting reading. The authors must have spent an enormous amount of time in compiling this and in the bibliography there are no less than 720 references, a high proportion of them dealing with the historical survey. In fact, there are but few references dated later than 1950, one exception being of course the authors' *Studies on the Nutritive Value of Bread and on the Effect of Variations in the Extraction Rate of Flour on the Growth of Undernourished Children* (Spec. Rep. Ser., Med. Res. Coun., London, No. 287, 1954).

In Chapter VI, entitled "Return to Plenty (1921-1939)" the authors say (p. 80): "By 1938 or 1939 so much indirect and circumstantial evidence in favour of wholemeal bread had been collected, accepted and publicised that its advocates had convinced almost everyone that what was said was true. Questioners' motives were suspected and their evidence brushed aside. Everyone interested in health had to believe or pretend to believe that people should eat brown bread."

The last two chapters of the book are an account of the investigations made in German orphanages by the authors in 1947-1949, although this was not published by H.M. Stationery Office until 1954. This work was carried out for the Medical Research Council to obtain factual information on the relative values of white bread, both enriched and unenriched, on bread made from flour of 85 per cent extraction and of wholemeal bread. It is therefore perhaps not surprising in view of the quotation taken from p. 80 and reproduced above that the authors unequivocally state in the preface: "The results which we obtained surprised us very much at the time for in spite of all that we had been led to believe, white bread turned out to be just as good as brown, and all kinds of wheaten bread to have a nutritional value far in excess of anything we had been led to suppose."

"We came to the conclusion that our ideas had been wrong and we have set down our reasons for thinking so. The reader will also find a summary of the experimental test that did not give the results we had anticipated, and the steps we took to check it by further work."

Although many workers in this field are aware of this work and of the influence it must have had on what is called the 'Cohen Report,' *i.e.* the Report of the Panel on the Composition and Nutritive Value of Flour, the world in general may not know what may be to them astounding facts. Some authorities have queried the validity of the results of the 'German children' experiment but a study of Chapter VIII entitled "Progress by Experiment" should really dispel such queries. Throughout the book the theme is: "Why think, why not try the experiment"—advice given in a letter from John Hunter to Jenner in August, 1775. It is not surprising, therefore, that the authors' view is that the question of white versus brown bread is a subject where feelings have been strong and logic weak. What will interest chemists and others interested in this controversy are the statements made on pages 126 and 127, dealing with the experiments the authors planned and made. "The experiments showed firstly that wheat flour had a food value for growing children far beyond that usually assigned to it within recent years. The implications of this are great, particularly in parts of the world where flesh and milk are scarce and expensive. Secondly, they made it clear that unenriched white flour was just as valuable a constituent of the diets used at the orphanages as whole wheaten meal."

Nobody will doubt the authority of the authors to speak on their subject *Breads White and Brown.* Nobody will query their disinterestedness in a subject where partisan feelings have always run high. They themselves were surprised at their results, which were checked and re-checked carefully by additional

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experiments. However, as independent and honest investigators they have stated their views frankly and fearlessly, and it will be hard to discount them.

We believe that there are large numbers of chemists interested in this important subject, and for an impartial and revealing survey we commend this fascinating book, especially to those to whom history makes its appeal and who await, almost as one does in an absorbing thriller, the denouement in the final chapters.

D. W. KENT-JONES

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Laboratory Control of Dairy Plant. J. G. Davis. Pp. xii + 395. (London: Dairy Industries Ltd., 1956.) 30s. net.

In his preface Dr Davis states that this work is an attempt "to describe in simple language those tests which are now accepted as an essential part of plant control in order to ensure not only compliance with the regulations under which the dairyman has to work, but also to help him attain the highest possible efficiency in the management of the dairy." Dr Davis further affirms that no attempt is made to deal with plant operation, installation or maintenance; only methods for plant control are dealt with, together with "a certain amount of discussion of the background and reasons for the test."

Any book dealing with the laboratory control of dairy plant—or indeed of the plant control of any industry such as food processing, brewing or soft drinks—must go far beyond a straightforward textbook of methods of analysis. It is fundamental in such industries that the laboratory is only one of a number of tools essential for the highest efficiency. This must be the meaning of the author's reference to discussion of background and reasons for tests. It is not sufficient to use a test proved to be thoroughly reliable under ordinary laboratory conditions when such conditions do not apply in the factory. The question arises; does the result of the test actually assist in the conduct or maintenance of the optimum working of the plant, or does it merely throw a light on certain possibilities. This kind of problem is illustrated by the author when discussing adequate protection from harmful bacterial infection. In the chapter on sterilants full working details are given of a modification of the Rideal-Walker and Chick-Martin tests for determining the efficiency of disinfectants, the modifications being the use of milk as a supplement and litmus milk in place of broth. The reasons for the modifications are stated, namely, that the Rideal-Walker test is restricted to absence of organic matter and that the use of faeces or yeast as a standardised form of organic matter in the Chick-Martin test does not apply where the organic matter is in the form of milk solids. The description of the modified method and the explanation cover just over three pages in the book. But the author further makes the observation that there are basically two types of methods available for the measurement of the bacteria-killing powers of disinfectants; one, those of the Rideal-Walker type, which measure the efficiency of the disinfectant, and the other, those which measure the viable organisms remaining after disinfection has taken place. For consideration of the latter attention is directed to an earlier chapter in the book which deals with the assessment of the cleanliness and sterility of plant. Here are given full working details of the use of swabs and Ringer solution, the plating out in suitable media, the time and temperature of incubation and the practical interpretation of the results. The author makes no personal claim for these tests. They are mainly based on methods devised by the Technical Committee of the National Milk Testing and Advisory Scheme in 1942. The tests apply to the plant, to milk bottles and to milk cans and tanks. In certain instances, where applicable, other methods by direct testing *in situ* with agar media are referred to. In contrast to the space covered by the description of the first-mentioned type of method this description of the second type covers some 12 pages of the book.

The first chapter in the book deals with the purpose of plant control; the second with the principles involved in the cleaning and sterilisation of plants. In the latter two useful tables setting out the principal properties of common detergent solutions and their killing times for *B. Subtilis* follow brief accounts of the various ways of effecting cleanliness and sterilisation.

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Chapter 3, covering methods of assessing the cleanliness and sterility of dairy plants, includes a wide range from rule-of-thumb methods onward. In connection with testing for cleanliness, brief details are given of physical methods such as powder dusting, dye-staining, colony counts, and a chemical assessment based on chlorine absorption by residual organic matter. There is much of interest in the account of these practical dairy operations, as, for example, the details of a lip-stick test developed from the observation that lipstick is a type of soiling difficult to remove from the beer glasses of licensed premises. The methods for assessing sterility have been referred to earlier, but further information is given about the use of a bacteriological examination of the "first milk through" a plant for the purpose of gauging all-over sterility, and about the special significance of the examination for thermoduric organisms, *i.e.* the organisms surviving pasteurisation.

Plant control is discussed at considerable length in the fourth chapter and naturally is very technical more or less throughout. The first part dealing with control of the pasteurisation process opens with an explanation of the mathematics involved in determining the time taken "by the fastest particle through," this being of major importance in order to cope with the legal requirements for H.T.S.T. pasteurisation—*i.e.* the rapid heating of the milk to 161°F, its retention at that temperature for 15 seconds, and its immediate cooling to 50°F—when working with thousands of gallons of milk an hour. Then follows an account of the methods actually used in practice for the purpose of measuring the "holding time." Next sterilised milk, *i.e.* milk heated to a temperature of about 220° to 230°F, is considered, and the difficulty arising from the presence of thermophilic bacteria is discussed. Finally there is information about pre-heaters, clarifiers, coolers, homogenisers and other such commercial equipment.

The next two chapters are short and are concerned with the "setting and checking of instruments" and "bottles."

Chapter 7, on detergents, is of considerable analytical interest. All the known types of detergents are considered; alkalis, polyphosphates and anionic, cationic and non-ionic synthetics. Methods for determining pH and the quantitative analysis of detergent mixtures are given in relatively full detail. The assessment of the value and measurement of the strength of detergent solutions is considered, and the theory and practice of conductivity methods are set out at some length.

That part of the next chapter on sterilants dealing with the assessment of the bactericidal power and efficiency of disinfectants has been referred to earlier. The remainder of the chapter deals almost entirely with chlorine from all points of view, except for a final short note on quaternary ammonium compounds. Chapters 9 and 10 deal with water and effluents respectively, and in such detail as to cover some 40 pages. Actually they are concerned with the well-known chemical and bacteriological methods of examination. There are full details, however, of a comparatively new method for estimating the strength of crude effluents which is of increasing interest, this being, in effect, the determination of organic matter by oxidation with acid dichromate solution.

Refrigerants, steam raising, corrosion and volume and weight measurements are briefly dealt with in the following four chapters. Under steam raising there are notes on flue-gas analysis and boiler feed-water conditioning against such troubles as caustic embrittlement and priming. The seven pages into which corrosion is condensed do not of course do justice to a universal trouble that is now receiving much theoretical consideration. Following these four chapters is a short one of 14 pages on trace-metals problems, which opens with the effect on milk and milk products of such contamination and then gives details of up-to-date colorimetric micro-methods of analysis for aluminium, calcium, chromium, copper, iron, magnesium and tin. The last chapters deal with miscellaneous materials and processes, and economic and legal aspects. Finally there are no less than 18 pages of references.

This is an outstanding book of its kind, a manual of laboratory control, not a textbook on milk analysis, yet having a very valuable analytical integration. Although it treats only of dairy plant whose raw material is a daily flow of thousands of gallons of milk and whose final product is that same milk, cleaned and purified, yet the general principles and practices it sets out are applicable, with

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scarcely any limitation, to the laboratories of any other industry dealing with perishable foods, food products or drinks. To deal adequately with such forms of control in a small volume of less than 400 pages is no mean task; it requires academic, technical and commercial experience. If the measure of success be in a steady and continuous call on this book in conferences, consultations and laboratories, then Dr Davis should be happy.

GEORGE TAYLOR

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Progress in Nuclear Energy. Series III. Process Chemistry. Volume I. Edited by F. R. Bruce, J. M. Fletcher, H. H. Hyman and J. J. Katz. Pp. xii + 407. (London: Pergamon Press Ltd., London, 1956.) 84s. net.

This volume is the first of a series dealing with progress in the process chemistry field of nuclear energy. Seven other series are being published to deal with other aspects.

In the eight chapters of this book are described methods for the extraction of uranium and thorium from their ores, the dissolution of reactor fuel elements and the principles and practices of radiochemical separation processes. Of the 36 papers presented, 15 are new and the remainder are revised versions of those originally presented at the Geneva Conference in 1955. Together they supply a wealth of information on what was formerly a classified field of knowledge.

After the opening chapter, which deals with the extraction chemistry of uranium and thorium, follow six chapters covering the whole field of fuel element processing. They take the reader naturally from a definition of the problems, through an account of laboratory experiments to a description of the various alternative processes which have been operated at full scale. Thus paper 5-1 by Thompson and Seaborg describes the bismuth phosphate process, which though now of historical interest only, nevertheless remains as the first successful process for the production of plutonium. Solvent extraction processes inevitably take up a large part of the text, since they are the present accepted methods and are well established. At a time when the industrial application of nuclear energy is uppermost, it is pleasing to report that two papers in Chapter 2 deal with the economics of chemical processing, a subject which becomes of ever-increasing importance. This is underlined by the present efforts of all the major countries in the field to discover acceptable processes which avoid the obvious disadvantages from which solvent extraction methods suffer, *viz.* the need for complete dissolution of the irradiated fuel elements, followed by the many subsequent steps needed for purification and refabrication.

Chapters 6 and 7 describe current work on such alternative processes which, in concept at least, hold out the promise of greatly reduced processing costs. Whereas by the fluoride process of Chapter 6 the number of stages is reduced, the pyrometallurgical approach described in Chapter 7 goes further by seeking to retain the fuel at all times in the metallic state. These chapters objectively describe the particular difficulties associated with these methods. An important point is made, of increasing significance as fuel elements are subjected to increasing irradiation dosages, that though radiation damage to the reagents used in solvent processes may possibly be a future limitation on these, the non-solvent processes employ purification steps which are not susceptible to radiation damage. Thus the irradiated fuels can be processed after a minimum decay period, with a consequent decrease in the amount of idle fuel. As a completely different approach to the economic utilisation of fissile material, the paper 5-8 by Ferguson, dealing with the processing of homogeneous aqueous reactor fuel, though brief, is of interest in pointing to possible future developments.

The last chapter deals, of necessity somewhat superficially, with the recovery of useful radioisotopes from chemical process wastes. This subject, deserving of a volume to itself, cannot be more than touched upon sketchily in 31 pages.

Three useful appendixes, a glossary and an index complete the book.

The editors have achieved a considerable measure of success in selecting and converting into a coherent whole a number of papers which, because they were written as separate entities, vary considerably in quality and style, ranging from

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near sketch outlines to detailed descriptions and schematic flowsheets. Nevertheless the complete work stands as probably the most complete exposition to date of the chemical and chemical engineering aspects of reactor technology.

The book is well produced, and the few errors (pp. vi, 219, 228f., 273) that were noted are sufficiently obvious not to mislead. The index could be improved, and the system of cross-referencing by section numbers, though adequate, is surely less convenient than a simple page reference system.

K. SADDINGTON

Sodium: Its Manufacture, Properties and Uses. M. Sittig. Pp. viii + 529. (New York: Reinhold Publishing Corporation; London: Chapman & Hall, Ltd., 1956.) 100s. net.

New developments and new uses are bringing sodium increasingly to attention. As a heat transfer agent, as a reducing agent in titanium production and in organic reactions, and in other directions, uses grow. The time is therefore opportune for a monograph on the subject.

"Historically," the author says, "much sodium production has been restricted to 'captive' uses, and only in recent years has it been available to all industry in large quantities." This seems an unusual way of looking at the fact that, until recently, only manufacturers of sodium were interested in its uses. One cannot imagine that at any time they would have been averse to receiving large orders.

There have only been two successful processes for manufacturing sodium. The first was the product of the inventive genius of an American, Castner, who came to England some 70 years ago to exploit his invention and also his process for making the pure caustic soda which was essential in the electrolysis he employed. That process is now dead, but a very useful account of it was given recently by Wallace. It was supplanted by Downs's process for electrolysing fused salt. There have been many other processes proposed, some even reaching a manufacturing scale for a time, and a chapter is devoted to a review of these various processes.

This monograph covers a very wide range of subjects: solubility and alloy systems; reactions; physical properties. The analytical aspect is not neglected, whilst uses of the metal as such, and in chemical reactions, are considered in separate chapters. A good deal of attention is devoted to handling, and the recent development of electromagnetic pumping is described. Obviating glands, and the only moving part being the sodium, this invention greatly facilitates the transfer of the metal, *e.g.* in heat transfer systems.

It is a pity that in such an admirably planned and welcome volume there should in many places be a lack of balance and of critical consideration, and at times an inadequacy of treatment. Thus criteria for obtaining good results in electrolysing fused salt are given (p. 25), but it is not mentioned that they were advanced by Borchers 60 years ago; in stating that no metallic object should be present between the electrodes, they suggest that its diaphragm must make the Downs cell unworkable. In the section on physical properties, an inordinate amount of attention (47 pages) is given to a comprehensive study of the vapour pressure of sodium, going closely into the dimerisation occurring in sodium vapour. And—a trap for the unwary—the detailed results of investigators of the physical properties are given in the first part of this chapter, whilst in an appendix the best estimates are given over the whole temperature range, at 5°C intervals, including a further nine pages of vapour pressures.

Other examples could be given, *e.g.* the information on a recent proposal to make sodium from fused salt with a molten lead cathode (p. 37) is not related to the German work in which it originated (F.I.A.T. Final Report 830). The attribution of the diagram on p. 69 should be to Rinck, and not to Lorenz and Winzer, who in fact were guilty of a classical howler. In places the treatment is ingenuous, *e.g.* the $CaCl_2$–Na equilibrium on p. 235. "The white coating on commercial sodium bricks is largely sodium hydroxide, according to Yamaguti.[70]" And what, one wonders, is 'analyzation'? (p. 144).

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The reader will therefore have to take this useful publication with some reserve, and we shall still await the publication of a monograph that shall be as critical, thorough and well balanced as it is reliable. H. R. LEECH

Chromium. Volume I, Chemistry of Chromium and its Compounds. Edited by M. J. Udy. Pp. xiii + 433. (New York: Reinhold Publishing Corporation; London: Chapman & Hall Ltd., 1956.) 88s. net.

Chromium and chromium compounds play an important role in our daily lives. Chromium metal brings brightness to our homes and chromium chemicals are widely used in various textile and tanning processes and as attractive coloured pigments. The American Chemical Society has decided that there is room for an up-to-date monograph on the science and technology of chromium and has secured the assistance of no less than 36 authors to write authoritatively on their special fields of interest.

The monograph is in two volumes. The first volume deals with the history of chromium, mineralogy and geology of chromium, the chemical and physical properties of chromium compounds and their manufacture and uses. The second volume is concerned with the metallurgy of chromium and its alloys. Volume I opens with a short account of the history of chromium by the editor, M. J. Udy. It is followed by an excellent chapter of some 38 pages by T. P. Thayer of the U.S. Geological Survey, in which he discusses the problems of composition, physico-chemical behaviour and the genesis of chromite, one of the relatively few minerals used as a source of chromium and its compounds. This survey concludes with an assessment of the chrome ore resources of the world.

The relation of chromium to health is the title of an interesting and important article by A. M. Baetjer. He states that it is believed that pure metallic chromium is biologically inert and exerts no harmful effects on the body and that chrome ore is also harmless. On the other hand, it is well known that the hexavalent compounds exert an extremely irritative, corrosive and, under some circumstances, a toxic action on the body tissues. Dr Baetjer discusses measures which may be adopted by industries to prevent the harmful effects of chromium compounds, and he outlines types of treatment. He emphasises the need to keep abreast with the medical literature as the methods of treatment are constantly changing and improving.

The analytical chemistry of chromium is particularly fascinating because of the precision and accuracy of the methods available for its estimation. The chapter in which this is discussed is up-to-date and contains a useful list of references.

The second section of the volume begins with a chapter of some 137 pages in which the editor discusses the physical and chemical properties of the non-metallic compounds of chromium. Obviously the selection of material presents a formidable problem, but the author has solved this most successfully. The book concludes with chapters in which the major uses of chromium chemicals are considered in detail. Various authorities discuss chromium chemicals in the textiles industry, in the tanning industry, in the oil and gas industries, in the graphic arts and also in wood preservation and in corrosion prevention. It is interesting to know that the mechanism of chrome tanning cannot yet be adequately explained in spite of the voluminous literature on the subject. A useful feature of each chapter is the list of references given at the end. The chemical monographs of the American Chemical Society are well known, and this new volume fully maintains the high standard of these books.

W. WARDLAW

Organic Chemistry. Volume II. Stereochemistry and the Chemistry of Natural Products. I. L. Finar. Pp. xii + 734. (London: Longmans, Green & Co., Ltd., 1956.) 40s. net.

Since its publication in 1951, the first volume of "Finar," now in its second edition, has become a standard textbook of organic chemistry. It deals with

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fundamental principles and, as stated in a previous review (*J.*, 1954, 420), its publication marked the replacement of a stage-by-stage approach to organic chemistry by one based on a constant feed-back of modern ideas to junior classes. Volume II, which is on slightly more stereotyped lines, relates mainly to the application of the basic material of Volume I to the study of natural products. A recital of the chapter headings will show the scope of the work: physical properties and chemical constitution; optical isomerism; Walden inversion; geometrical isomerism; stereochemistry of diphenyl compounds; stereochemistry of some elements other than carbon; carbohydrates; terpenes; carotenoids; polycyclic aromatic hydrocarbons; steroids; heterocyclic compounds containing two or more hetero-atoms; amino acids and proteins; alkaloids; anthocyanins; purines and nucleic acids; vitamins; chemotherapy; haemoglobin, chlorophyll, and phthalocyanins.

It is obvious on reading this volume that a great deal of careful scholarly work has gone to its making. Much information not readily available to a student has been accumulated, digested and clearly presented. A real effort has been made to keep up to date. Thus we have Woodward's steroid synthesis and Fodor's elucidation of the configurations of the tropines. The chapters on stereochemistry and on the major natural products (*e.g.* steroids, terpenes and nucleic acids) are excellent. Particularly praiseworthy are the relevant reading references at the end of each chapter.

Minor criticisms are of course inevitable. In an advanced textbook it is impossible for any one author to have a detailed knowledge of all that he treats. A reader, on the other hand, can have odd scraps of fortuitous specialised information which enable him to fault the author on specific points. The chapter on anthocyanins discusses anthocyanidins and flavones but says nothing of the other flavonoids which are also members of the hierarchy of the propane bridge. The flavone syntheses described are over 30 years old; no mention is made of the important Baker-Venkataraman or Algar-Flynn-Oyamada reactions. There is, and this is more serious, no discussion of the absolute configuration of steroids or terpenes and little mention, outside the reading references, of conformational analysis, which represents a major advance in modern chemistry. Organic chemistry is chiefly hybridised *s* and *p* orbitals, and although the author says much and says it well about spatial effects, one could do with more—and what a pity he still clings so tenaciously to the solid tetrahedron.

Reading this generally excellent book, written for honours students, one wonders if we will not have, sooner or later, to revise our ideas about what constitutes an honours course. The development of theory has effected such unification of organic chemistry that there is a decreasing need for specialised training in the separate families of natural products. The advanced textbook of the future, if one may hazard a guess, will contain chapters corresponding to the first six and the twelfth chapters of this volume, together with a lot on conformational analysis and reaction mechanisms of all types. There will be something, but not too much, about a few families of natural products based mainly on biogenetic considerations. Writers of future advanced organic textbooks will have to meet increasing competition from *Quarterly Reviews* if a tendency to over-elaboration in articles in this periodical can be eliminated.

However, all this is for the future. We write textbooks when young and suggest how others should write them as we age. For honours students as at present taught this is a very good book. It represents all one could expect from one man, covering a wide range of chemistry. It makes an admirable sequel to the first volume; and if at times it seems overloaded with detail and to expect too much of the student's memory, blame the professors and do not blame the author.

T. S. WHEELER

Quantitative Problems in Biochemistry. E. A. Dawes. Pp. ix + 224. (Edinburgh and London: E. & S. Livingstone Ltd., 1956.) 21s. net.

As the science of biochemistry progresses, the approach of the research worker must become more and more that of a physical chemist, although undoubtedly that of a physical chemist of a highly specialised type. The equipment required

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in these rapidly advancing fields is of necessity both expensive and delicate, so that the problem of undergraduate teaching becomes acute, especially in those smaller departments which cannot have available all the more specialised types of apparatus. In these circumstances much of the practical teaching must take the form of lectures, supplemented where possible by demonstrations. Dr Dawes has thus made a valuable contribution to this aspect of teaching by producing a collection of numerical problems, many taken from the original literature, to illustrate these modern physical methods. This approach to the teaching problem is a vital one; if the apparatus itself is not available for study then the only sure way of understanding the principles, and techniques, involved is to solve the numerical problems which arise in the everyday use of the apparatus. The collection of problems provided in this book will be of tremendous value to the student and teacher alike.

The general arrangement of the book leaves little to be desired, although some minor criticisms of the choice of material might be made. Such a choice must be governed by the author's own interests. The topics dealt with include the relatively modern techniques of the ultra-centrifuge and the tracer laboratory, as well as the old established ones of manometry and spectrophotometry, while the more theoretical problems of reaction kinetics are not forgotten. Perhaps the only important subject which is not treated is that of statistics. Although physical methods are becoming of increasing importance in biochemistry, the science is still primarily a biological one, so that the statistical control of biochemical experiments might well have been emphasised. A chapter on these statistical methods, which are of greatest importance to biochemists, would have been a most valuable addition to the book. Quite apart from the more biological aspects, the importance of the method of least squares in drawing 'the best straight line' for the graphical solution of problems surely justifies a fuller treatment than the few lines given. Apart from this, however, it is difficult to criticise the author's choice of material.

Although the book is primarily a collection of problems, some of which are worked out as examples, there is included a sufficiently detailed treatment of the theoretical background to allow a ready solution of the problems without recourse to a text in physical biochemistry, which the present volume in no sense claims to be. It should perhaps be mentioned that solutions of the numerous problems are provided for the student.

The book has apparently been designed for use by honours students in biochemistry, but it deserves a much wider circle of users. Many of the chapters would be suitable for the earlier stages of biochemical teaching—indeed, the standard reached in some of them does not always seem to be as high as might be expected in an honours textbook. Again, the whole book will prove of great value to those numerous workers, in many fields, who wish to enlarge their knowledge of the modern techniques of physical biochemistry.

A. B. ROY

The Chemical Constitution of Natural Fats. T. P. Hilditch. Third Edition. Pp. xix + 664. (London: Chapman & Hall Ltd., 1956.) 95s. net.

This edition incorporates completely re-written chapters, *e.g.* chapters 5, 6 and 7, dealing with component glycerides. There has been considerable development here due to our rapidly increasing knowledge both of technique and of the glyceride structure.

Similarly, considerable advance has been made in our knowledge of the constitution of individual fatty acids, many of which can now be prepared by synthetic methods. Professor Hilditch has re-written this section of the book in the light of modern knowledge and has been able to present a more logical classification or grouping based on structural considerations.

Under experimental technique in ultra-violet spectrophotometry there is a summary of references to studies of conjugated polyethenoid linkages; one would have liked to have seen more reference to infra-red technique and its value in elucidating the constitution of autoxidised oils and their component acids.

J. H. SKELLON

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INSTITUTE AFFAIRS

GRADUATE MEMBERSHIP EXAMINATIONS, APRIL, 1957

Part II, with Part I (b)

Theoretical examinations (Part II) and the German translation test (Part I(b)) will be held in London and Newcastle upon Tyne and, if required, in other centres, on **Monday and Tuesday, 1 and 2 April, 1957.**

Practical exercises will be carried out in London and Newcastle upon Tyne on **Wednesday to Saturday, 3 to 6 April**, inclusive, and in London on **Wednesday to Saturday, 27 to 30 March, and Tuesday to Friday, 9 to 12 April,** inclusive.

Candidates will be asked to state their preference as to the centre for their theoretical papers and the period and centre for their practical exercises, but it must be clearly understood that no guarantee can be given that their wishes will be met.

Candidates who have not yet been accepted for examination and who wish to present themselves in April should obtain from the Assistant Registrar without delay the prescribed Application Form, so as to allow ample time for obtaining the necessary signatures certifying that they have complied with the Regulations concerning their courses of training. **The completed Application Forms must reach the Institute not later than Monday, 14 January.** No application will be considered if received after that date.

Entry forms will be sent as soon as they are ready to all accepted candidates. **The last date for the receipt of Entry Forms is Monday, 4 February.** No Entry will be accepted if received after that date.

NOMINATION OF GENERAL MEMBERS OF COUNCIL

In accordance with the provisions of By-law 23(*c*) the following General Members of Council are due to retire at the Annual General Meeting on 5 April, 1957, and are ineligible for re-election in that capacity or for election as District Members of Council:—

Jack Wheeler Barrett, B.SC., PH.D., A.R.C.S., D.I.C., A.M.I.CHEM.E.
Harold Cordingley, B.SC., PH.D., M.ED.
Charles Horace Gray, D.SC., M.D., A.R.C.S., M.R.C.P.
Donald Holroyde Hey, PH.D., D.SC., F.R.S.
Herbert Henry Hodgson, M.A., B.SC., PH.D.
John Idris Jones, D.SC.
Ronald George Wreyford Norrish, PH.D., SC.D., F.R.S.

Seven General Members of Council are therefore to be elected at the Annual General Meeting in 1957 to fill these vacancies. The Council will in due course make nominations for this purpose under By-law 25(*d*). Other **nominations under By-law 26** are now invited and must be delivered at the Institute **not later than 1 February, 1957.**

[By-law 26 reads:—

26 (1) Any ten corporate members, not being Members of the Council, may nominate an eligible Fellow as a candidate for election as a General Member of the Council but no corporate member shall concur in nominating more than one such Fellow at any particular election.

(2) Any nomination made under this By-law . . . shall be in the following form:—

"We, the undersigned, being corporate members of the Royal Institute of Chemistry do hereby certify that A.B. of (registered address), a Fellow of this Institute, is, in our estimation, a fit and proper person to be a General Member of the Council of the Institute, and we do hereby nominate him as a Candidate for election as a General Member of the Council."

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(3) Any such nomination may consist of several documents in like form, each signed by one or more corporate members, and shall be accompanied by a statement by the candidate that he is willing to accept such nomination.]

When considering making nominations under By-law 26, corporate members may wish to be reminded that:—

(*a*) Nominations for District Members of Council were invited in November (*see* p. 628), and the notice included a complete list of present District Members of Council showing which were ineligible for re-election. As this issue will have gone to press before the closing date (10 December) for receipt of such nominations, publication of the list of nominees will be deferred to January. It will be understood, however, that any Fellow who has been nominated for election as a District Member is ineligible for nomination as a General Member of Council.

(*b*) Present General Members of Council who are due to continue in that capacity after the Annual General Meeting, 1957, are:—

Until the A.G.M., 1958: Dr Norman Booth, Professor E. G. Cox, Dr W. M. Cumming, The Earl of Halsbury, Dr Frank Hartley, Professor H. N. Rydon and Professor M. Stacey.

Until the A.G.M., 1959: Mr W. G. Carey, Professor F. Challenger, Sir Alfred Egerton, Dr R. A. E. Galley, Dr C. W. Herd, Dr F. Roffey and Dr P. F. R. Venables.

(*c*) It will be for the Council to make nominations in due course under By-law 22, to fill vacancies among Officers that will occur at the Annual General Meeting, 1957, through the retirement of the following:—

President:
Douglas William Kent-Jones, B.SC., PH.D.

Vice-Presidents:
Sir Ian Heilbron, D.S.O., PH.D., D.SC., HON.LL.D., F.R.S.
George Herbert Moore, M.SC., F.P.S.
Ernest James Vaughan, M.SC., A.R.C.S., D.I.C., F.I.M.

The following Vice-Presidents are due to continue in that office until the A.G.M., 1958: Mr R. C. Chirnside, Dr R. B. Strathdee and Sir Alexander Todd.

SPONSORSHIP OF FORMAL MOTIONS BY MEMBERS AT GENERAL MEETINGS

In accordance with the promise given by the President at the conclusion of the Special General Meeting on 19 October, the Council has re-examined the implications of the proposal to increase from one to twenty the number of members required to sponsor a formal motion for submission at a General Meeting of the Institute. The discussion at the meeting and the views expressed in letters from members have been very carefully considered, and it is clear that some criticisms have arisen from misunderstandings as to the purpose and effects of the proposal.

In opening the discussion at the meeting, the President pointed out that there was no truth in the suggestion that the resolution was designed to prevent any comment by members at General Meetings and emphasised that all members would continue to have the opportunity of referring to any subject affecting the Institute when the Annual Report of the Council was presented for consideration. Nevertheless, several speakers opposing the motion ignored this statement and implied that any restriction on the submission of a formal resolution would effectively stifle free discussion. One speaker referred to the "possible effect of throttling freedom of speech which has been a refreshing characteristic of those meetings which I have attended"; but this remark suggests a further misapprehension as only three motions from private members have been submitted at General Meetings since 1916. In view of the member's assertion, however, it must again be emphasised that the proposed amendment to By-law 4(2) affects solely the conditions under which a *formal motion* may be submitted to

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a General Meeting; it does not affect freedom of discussion on matters arising on the Annual Report of the Council or on the statements by the President and Honorary Treasurer in presenting the Report—which covers every activity of the Institute.

Matters submitted as formal motions are in a special category as they may, and generally do, have a legislative effect. Motions submitted by the Council are proposed only after very careful consideration and approval (usually without dissent) by a substantial majority of its forty-eight members. The view that a formal motion proposed by private members should also have received the prior consideration and support of a reasonable number of members is reinforced by the fact that some such provision is a usual feature of the constitutions of corporate bodies of all kinds.

At the meeting much was said of the difficulties of the isolated member in this matter, but the Council adheres to the view that if such a member has what he believes to be a valuable idea which might involve a change in the constitution or a modification in the policy or practice of the Institute, he should not expect to go immediately to the length of putting forward a formal resolution at a General Meeting. There are many preliminary steps which he can and should take. By writing to the Secretary of the Institute he may obtain further information on the point he thinks of raising, for there may be considerations of which he was not previously aware that may cause him to modify his views. Numerous and varied enquiries of this kind are received in the Office and many are referred to the Council or its appropriate committees for further investigation. When the originator of a proposal is satisfied that it is worthy of wider consideration, he may decide to write a letter to the Editor of the *Journal* so that all members may be made aware of the views of himself and his colleagues. If, after such enquiries, it appears to the member that there are features in his proposal that make it worth pursuing, he should take the opportunity of discussing it informally with some of his fellow members by attending a meeting of his Local Section, or of raising it formally at such a meeting when this procedure is admissible (usually at a Local Section annual general meeting). Many such matters are discussed in Local Section meetings and may be referred to committees for further examination, or put forward at the Conference of Local Section Secretaries (held twice yearly) if an exchange of views among Section representatives is considered desirable. Formal resolutions passed at Local Section general meetings and the Report of the Conference are submitted as a matter of course to the Council and if a proposal appears to be of potential benefit to the Institute or the profession it may be adopted as, or incorporated in, a Council resolution for submission at a General Meeting of the Institute. Alternatively, it may properly be put forward as a private member's motion provided that a reasonable measure of support has first been obtained.

The Council believes that a substantial majority of members realise that the purpose of the proposed alteration to By-law 4 (2) is to ensure that there is sufficient evidence of such support. Many of the arguments against the resolution were based on false ideas as to its possible effects and might therefore have misled some of the members present at the Special General Meeting. It seems probable that, despite any shortcomings in the statement that accompanied the notice of the resolution, the general body of proxy voters—whose intelligence and judgment were treated with scant respect by at least one of the opposition speakers—arrived at a more enlightened conclusion about the purpose and effect of the resolution than some of the members present at the discussion.

The Council has therefore adhered to its earlier conclusion that the amendment to the By-law is reasonable and in the best interests of members. Moreover, it is considered that the overwhelming vote in favour of the resolution is a clear indication of wide support that cannot properly be ignored. It has therefore been decided that the new By-law shall be submitted to the Privy Council in accordance with normal procedure. If it is approved and the safeguards so afforded become operative, the Council will readily accept the request that the sponsors of a private member's motion should be given the opportunity to issue with the notice of a General Meeting a concise statement in support of their

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proposals. It must, however, be open to the Council, in virtue of its responsibility for the development of the general policy of the Institute, to issue at the same time a statement of its own views on the matter.

VOTING ON RESOLUTIONS AT GENERAL MEETINGS

The Council has also reviewed the procedure relating to voting at General Meetings and has considered the question of accepting amendments to resolutions.

At the Special General Meeting the system of voting on resolutions was criticised on two grounds:—

(*a*) It seemed that the Meeting was powerless in the face of votes already cast by directed proxy and that a very unsatisfactory position arose when the result of a vote by show of hands at the Meeting was reversed when a count was demanded and proxy votes were brought in.

(*b*) The Chairman had ruled that no material amendments to a resolution could be accepted because of the definite voting instructions already given by those who had completed directed proxies.

Attention may first be drawn to the principal features of the present system in comparison with the procedure in operation before the By-laws were revised in 1951. It is emphasised that the only significant change made at that time was to provide that a member appointing a proxy to vote for him should be able, if he so wished, to direct how his vote was to be cast on each resolution submitted. Under the earlier By-laws, a member appointing a proxy was obliged to leave it to the discretion of the proxy, after hearing the discussion on the resolution, to cast the vote as he thought fit. It is still possible for a member to do this if he wishes. Under the present By-laws, as under the old, a member may appoint as his proxy either the President or any other corporate member. A member appointing a discretionary proxy may think it advisable to choose someone who is believed to hold views similar to his own on the subject of the resolution and is therefore likely to cast the vote as he himself would have done. On the other hand, it is immaterial who is appointed as a directed proxy, for he must then vote as he is told. Thus, the President may be directed to vote against a Council resolution or for a resolution which the Council opposes.

The provision for voting by directed proxy was introduced to enable members unable to attend the General Meeting—a great majority—to exercise their full voting rights. Hitherto, the only concern expressed has been lest the proxy vote should not be included through lack of demand for a count. In order to safeguard the interests of proxy voters it has been made clear that the Chairman himself would feel obliged to demand a count on any controversial issue if no other member did so (*J.*, 1954, 379).

A clear distinction must be drawn between this provision for voting by directed proxy *before* a General Meeting and that for a **postal ballot** to be held *after* the meeting. By-law 11, which was not changed in 1951, provides that after the result of voting on a resolution has been declared, any ten members may demand a postal ballot before the close of the meeting. Twenty-eight days are allowed for sending out the ballot papers, following such a demand, so that time may be available to send with them a report of the proceedings at the Meeting. In these circumstances all members are informed of the discussion at the Meeting before they vote in such a ballot.

A demand for a postal ballot is most likely to be made when the voting on a resolution by show of hands at a Meeting goes in the opposite direction to the voting by directed proxy. When that happens, there may be reason to doubt if a majority of the proxy voters would have directed their votes as they did if they had heard the discussion at the Meeting. However, it does not follow that such a reversal *proves* this to be so. Nevertheless, in such circumstances there should be an opportunity of putting the matter to a further test, and the provisions for a postal ballot are intended for this purpose.

A question was asked at the Special General Meeting about the conditions under which a postal ballot might be held on the second resolution which was

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defeated on a show of hands but carried by an overwhelming number of proxy votes. The fact that no demand for a postal ballot was subsequently made may have been due in part to the ruling given by the Chairman that the resolution could not be amended before such a ballot was held.

The possibility of accepting amendments to motions must be considered as a separate issue which raises many new problems. The Council has been advised that where provision is made for directed proxies, no amendments of substance can legally be accepted. Even if discretionary proxies only are permitted and the proxy form refers to a motion 'or any amendment thereof' it would appear that the Chairman should not accept amendments to special resolutions. Apart from any legal principle or precedent involved, it would be difficult to find any practical basis on which to accept an amendment without prejudicing the rights of voters by directed proxy. The position would be difficult enough even if only discretionary proxies were allowed, for a heavy responsibility would still be placed on the Chairman if he had to decide which, if any, of several amendments he could properly accept. It might happen that the acceptance of an apparently beneficial amendment without the opportunity of considering its full implications would lead to wholly unexpected and undesirable consequences. Further legal advice is being sought on any possible procedure under which certain types of amendment might be acceptable. There is little doubt that the position would be simplified if it were decided to revert to the use of discretionary proxies only, but it is believed that many members would think this an undesirable restriction on existing voting rights.

The suggestion that a preliminary notice of a General Meeting should be circulated so that members would have an opportunity of submitting amendments for inclusion on a second notice has been considered. The principle is clearly attractive but the practical difficulties would be overwhelming. It would be virtually impossible to avoid complete chaos in the proxy voting if a number of contradictory or inconsistent amendments were received.

Although the established procedure may not be entirely satisfactory in all circumstances, the Council has concluded that no serious defect has been revealed. However, if after further investigation it is found that changes in the By-laws would be beneficial, recommendations will be submitted in due course.

MELDOLA COMMEMORATION DINNER

At the invitation of the President, Dr D. W. Kent-Jones, a company of 25 Meldola Medallists, the five living Past-Presidents and the present Officers and Vice-Presidents of the Institute met Officers of the Society of Maccabaeans at an informal dinner in the Trocadero Restaurant, London, on 16 October, after the Meldola Lecture on "The Chemistry of Dinitrogen Tetroxide" had been delivered by Dr Peter Gray at University College, London.

This Dinner—a most successful and historic occasion—marked the conclusion of thirty-five years of friendly collaboration between the two organisations, and it was a pleasure to all that Dr Percy E. Spielmann, F.R.I.C., who had represented the Society of Maccabaeans on all previous Meldola Award Committees, and Dr Stanley I. Levy, F.R.I.C., who has now succeeded him in that capacity, were also present.

It was on the retirement of Dr Spielmann last year that the Society expressed the wish to make a presentation to the Institute in commemoration of their happy relations since the time when it was originally decided to institute a Medal dedicated to the memory of Raphael Meldola (1849-1915), President of the Society from 1911 to 1915 and of the Institute from 1912 to 1915. The Commemoration Dinner owed its origin to the desire that this presentation should be made in appropriate circumstances.

The gift of the Society of Maccabaeans—an eighteenth-century pewter punch-bowl shown in the photograph opposite was presented by Sir Samuel Gluckstein, a present Vice-President of the Society and its President from 1934 to 1954, and was received by Dr Kent-Jones on behalf of the Institute.

The inscription on the bowl reads:

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Presentation by the Society of Maccabaeans

This Punch-Bowl was presented to the Institute at the Meldola Commemoration Dinner (p. 730)

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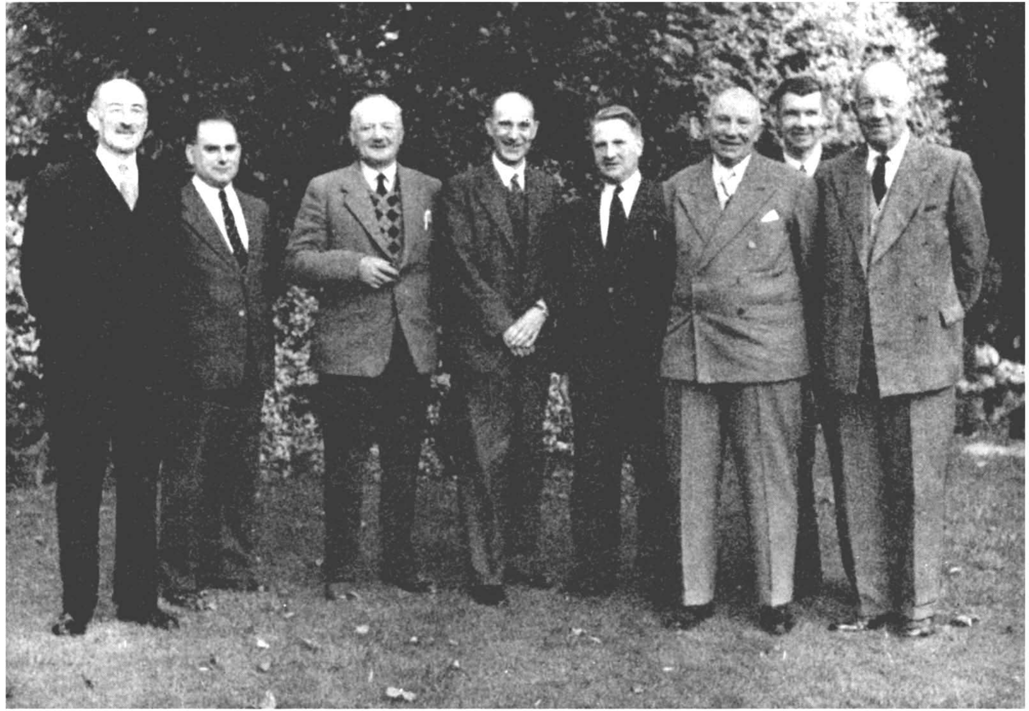

THAMES VALLEY SECTION INAUGURATION

Left to right: Dr H. J. T. ELLINGHAM, Secretary, R.I.C.; Dr E. S. LANE, Dr D. T. LEWIS, Dr P. F. HOLT, Members, New Section Committee; Dr C. H. BAMFORD, Chairman, New Section Committee; Dr D. W. KENT-JONES, President, R.I.C.; Mr A. A. SMALES, outgoing Committee Member; Dr R. T. COLGATE (*see* p. 747).

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"The gift of this bowl to the Royal Institute of Chemistry expresses the warm appreciation of the Society of Maccabaeans for the Institute's devoted care in the administration of The Meldola Award during 35 years, and also the Society's gratitude for the work of Dr Percy E. Spielmann, Member of Committee of the Society and Fellow of the Institute, on his retirement after his association with the award during the same period. 1921-1956."

On the same photograph the Meldola Medal is shown. The obverse carries a fine embossed head of Raphael Meldola, and the reverse gives details of the individual award.

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NATIONAL CERTIFICATES IN CHEMISTRY, 1955-56

In England and Wales there were three colleges submitting candidates for the first time in the Senior Grade and eight in the Advanced Grade.

The number of candidates entering in the Senior Grade was 1,893, of whom 1,184 passed (62·5 per cent), compared with 1,642 candidates in 1955, of whom 1,012 passed (61·6 per cent).

In the Advanced Grade there were 1,018 candidates of whom 710 passed (69·7 per cent). The corresponding figures for 1955 were 959 and 681 (71·0 per cent). Of the 1,018 candidates, 853 had previously obtained the Ordinary Certificate, and of the 710 successful candidates 590 held this Certificate.

In Scotland there were 342 entries in the Senior Grade, of whom 214 passed (62·6 per cent), and 210 in the Advanced Grade, of whom 127 passed (60·2 per cent).

In Northern Ireland Ordinary National Certificates were awarded to three of the 26 candidates, and Higher National Certificates to five of the eight candidates.

GRADUATE MEMBERSHIP EXAMINATION SEPTEMBER, 1956

REPORT OF THE EXAMINATIONS BOARD

Examinations were held as under:—

	Entered	Passed
Graduate Membership (Part II and Part I (b)):		
Examiners: Professor C. W. Davies, Dr H. M. N. H. Irving, Professor E. E. Turner.		
The examination was held at the University of London, South Kensington, at the University of Birmingham, at Chelsea Polytechnic, London, and at the Royal Technical College, Glasgow, theoretical papers being taken also at various local centres, in the periods 4 to 7 and 10 to 15 September, 1956.	313	50
The examination in Part I (b), for those candidates who were taking this part separately, was held at various local centres on 11 September, 1956	24	15
Postgraduate Diplomas:		
The examinations were held at the University of London, South Kensington, at the offices of the Institute and at the Post-graduate Medical School of London in the periods 17 to 22 September and 8 to 13 October, 1956.		
Branch D.1: Clinical Chemistry. *Examiners:* Professor E. J. King and Dr W. Klyne	1	1
Branch E: The Chemistry, including Microscopy, of Food, Drugs and Water. *Examiners:* Dr D. C. Garratt and Dr H. E. Archer	14	9

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Branch G: Industrial Chemistry, with special reference to the Plastics Industry.		
General Examiner: Dr W. Preston		
Special Examiner: Dr N. J. L. Megson	1	1
	16	11

Graduate Membership Examination, Part II (Final):

Of the 242 candidates taking the whole examination, 23 passed (9·5 per cent), 152 failed and 67 were referred (in theory only, 5; practical only, 7; translation only, 25; theory and practical, 2; theory and translation, 11; practical and translation, 17).

The remaining 71 candidates were repeating parts of the examination in which they had previously failed; 27 passed (38·0 per cent) and 44 again failed (theory only, 7 passed, 18 failed; practical only, 17 passed, 11 failed; translation only, 2 passed, 5 failed; theory and translation, 9 failed; practical and translation, 1 passed, 1 failed).

The overall percentage passing was 16.

PASS LIST

Angus, Henry John Flockhart, Heriot-Watt College, Edinburgh.
Arnold, Peter Edmund, Northern Polytechnic, London.
Bateman, Ralph John Charles, Northampton Polytechnic, London, and Sir John Cass College, London.
Benjamin, Colin, Glamorgan Technical College, Treforest.
Bird, Arthur, B.SC. (LOND.), Harris College of Further Education, Preston, and College of Technology, Liverpool.
Boden, Harold, College of Technology, Liverpool.
Brockington, John, College of Technology, Birmingham.
Carter, Terence Leonard, Sir John Cass College, London.
Collins, Robert Eric, Technical College, Brighton, and Luton and South Bedfordshire College of Further Education, Luton.
Culbert, Dennis Peter Alexander, Northampton Polytechnic, London.
Cushnie, Alexander James, College of Technology, Liverpool.
Dear, Robert Ernest Arthur, College of Technology, Bristol.
Duncan, Arthur Henry, College of Technology, Liverpool.
Graham, John Frederick, Acton Technical College, London.
Green, Gerald Ernest, B.SC. (LOND.), King's College, London, and Acton Technical College, London.
Greenfield, Bernard Frank, Technical College, Brighton.
Gussefeld, Gunter William, The Polytechnic, Regent Street, London.
Halewood, Gerard, College of Technology, Liverpool.
Hamilton, John Donald, College of Technology, Liverpool.
Harrison, Leslie, B.SC. (LOND.), College of Technology, Manchester, and Rutherford College of Technology, Newcastle upon Tyne.
Herniman, David William, College of Technology, Bristol.
Hunt, Robert Charles, College of Technology, Bristol.
Jackson, Douglas Valentine, West Ham Municipal College, London, and Woolwich Polytechnic, London.
Johnson, Derek Ivor Oliver, Acton Technical College, London.
Johnson, Eric George, College of Technology, Liverpool and Technical College, Birkenhead.
Kirkham, John, Harris College of Further Education, Preston and Northampton Polytechnic, London.
Knight, Leonard Cuthbert, Denbighshire Technical College, Wrexham.
Kuhnel, Mervyn Redfern, Mining and Technical College, Barnsley.
Lloyd, William John Warren, Technical College, Gloucester.
Macorkindale, James Byers, Technical College, Paisley.
Maycock, Percy, B.SC. (LOND), College of Technology, Chesterfield.
Miles, Norman John, Technical College, Newport (Mon.)

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Morgan, Peter Ernest, Technical College, Coventry.
Morton, George, Technical College, Paisley.
Owens, Dennis Raymond, College of Technology, Liverpool.
Paine, Derek Henry, Technical College, Brighton.
Palmer, Peter Joseph, College of Technology, Bristol.
Parton, Cyril, Technical College, St. Helens.
Ranson, Harry Christopher, B.SC. (LOND.), Queen Mary College, London.
Rawson, Douglas Hall, Technical College, Bradford.
Renwick, Gordon McArthur, B.SC. (ST ANDREWS), The University, St Andrews, and Technical College, Dundee.
Robbins, Derek, Harris College of Further Education, Preston.
Roberts, John, Technical College, St Helens.
Scott, Kenneth Alexander, Heriot-Watt College, Edinburgh.
Shipp, Horace Frederick, Battersea Polytechnic, London, and College of Technology, Art and Commerce, Oxford.
Smith, William, College of Technology, Hull.
Taubinger, Robert Pavel Ludovit Viliam, Technical College, Paisley.
Wilburn, Peter, College for Further Education, Stockport.
Williams, David Granville, Glamorgan Technical College, Treforest.
Worthington, William John, Wigan and District Mining and Technical College, Wigan.

PERSONAL NOTES

Honours and Awards

Professor R. D. Haworth, F.R.S., *Fellow*, has been awarded the Davy Medal by the President and Council of the Royal Society for his distinguished contributions to the chemistry of natural products, particularly those containing heterocyclic systems.

Dr K. G. A. Pankhurst, *Fellow*, has been awarded the degree of Doctor of Science of the University of London for published work in the fields of surface active substances and their reactions, particularly with proteins, and of leather science.

Dr J. M. Preston, *Fellow*, has been awarded the Warner Memorial Medal of the Textile Institute, in recognition of outstanding work in textile science and technology.

Societies and Institutions

Dr Bashir Ahmad, *Fellow*, General Secretary of the Pakistan Association for the Advancement of Science and Director of the West Regional Laboratories, Pakistan Council of Scientific and Industrial Research, has led a delegation of ten scientists to China as guests of the Chinese Academy of Science, Peking. They met leading Chinese scientists and visited various scientific centres and institutions. Dr M. I. D. Chughtai, *Associate*, of Punjab University, was also in the party.

Dr Douglas McKie, *Fellow*, Reader in the History and Philosophy of Science, University College, London, and a member of the commission appointed by the French Académie des Sciences to supervise the publication of Lavoisier's correspondence, has been elected Vice-President of the Académie Internationale d'Histoire des Sciences.

Association of Clinical Biochemists.—The following *Fellows* have recently been elected officers: President, Professor E. J. King; Chairman, Dr R. Gaddie.

Royal Society of Edinburgh.—Professor J. Norman Davidson, *Fellow*, and Principal H. B. Nisbet, *Fellow*, have been appointed Vice-Presidents, and Professor E. L. Hirst, *Fellow*, Dr D. N. McArthur, *Fellow*, and Dr A. G. McGregor, *Associate*, Councillors for the year 1956-57.

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Educational

Dr A. K. Chatterjee, *Associate*, has joined the staff of Birkbeck College as a lecturer in inorganic chemistry.

Dr N. L. Lahiry, *Associate*, has been appointed a Visiting Assistant Professor of Biochemistry by the Board of Trustees of Howard University, Washington, D.C., until the end of June next.

Mr J. Nicholson, *Associate*, Vice-Principal and Head of the Department of Science and Engineering of the County Technical College, Worksop, has been appointed Principal of the College of Further Education, Whitehaven, as from 1 January, 1957.

Mr G. S. Perry, *Associate*, holds a scholarship of the Fullers' Earth Union Ltd. at the Imperial College and is studying the intercalation of organic mixtures by clay minerals and the efficiency of such minerals in chromatographic separations.

Mr H. Price, *Associate*, has resigned his appointment as head of the department of chemistry, The Technical College, Port Elizabeth, on his appointment as Senior Lecturer, Chemistry Department, Rhodes University, Grahamstown.

Professor T. S. Wheeler, *Fellow*, University College, Dublin, will be in the United States on a lecture tour from 1 January for three months. Urgent letters will be forwarded.

Public and Industrial

Dr H. E. Blayden, *Fellow*, has resigned from his post as assistant director, the Northern Coke Research Laboratories, King's College, Newcastle upon Tyne, to take up an appointment as Superintendent of Fundamental Studies with the British Coke Research Association.

Mr George Brearley, *Fellow*, has been appointed director of the Association of British Chemical Manufacturers in succession to Mr J. Davidson Pratt, C.B.E., *Fellow*, who is retiring next June. In order to allow a period of overlap Mr Brearley will take up his appointment on 1 April, 1957.

Mr P. M. G. Broughton, *Fellow*, has recently been appointed Principal Biochemist to the Chelmsford Group of Hospitals.

Dr R. C. Cass, *Associate*, will relinquish his post of lecturer in inorganic chemistry at the University of Sheffield on 1 January, 1957, to join Borax Consolidated Ltd.

Mr L. J. Dent, *Associate*, has relinquished his post at Stafford Allen & Sons Ltd. to become development chemist and deputy chemist to the Farma Cream Product Co. Ltd., a subsidiary of United Dairies Ltd.

Dr H. M. Glass, *Fellow*, a Divisional Chief Technical Officer of the British Standards Institution, has been appointed Deputy Technical Director of the organisation.

Mr R. A. Langridge, *Fellow*, of Glaxo Laboratories Ltd., has been appointed an executive director.

Mr A. H. Latimer, *Associate*, has resigned from his position with Monkhouse & Glasscock Ltd. to take up an appointment as assistant analyst, Derbyshire County Council.

Dr G. L. Miles, *Fellow*, who has been working in the United Kingdom Atomic Energy Research Establishment at Harwell, recently returned to Australia to take up an appointment as Head of the Chemistry Section of the Research Laboratories of the Australian Atomic Energy Commission in Sydney.

Mr J. Ritchie, *Fellow*, has resigned as Director of the South African Bureau of Standards on his appointment as general manager of the Research and Development Department, Anglo-Vaal Industries, Johannesburg.

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Mr Harold Rose, *Fellow*, has relinquished his positions as technical adviser and director of Expandite Ltd., in order to resume his private practice as a technical consultant.

Mr W. Rosenberg, *Fellow*, has relinquished his post as senior chemist, Magnesium Elektron Ltd., to take up an appointment as assistant general manager, Thomas Mouget & Co. Ltd., Redcar.

Mr Harold Silman, *Fellow*, has been appointed a director of Wates Ltd.

Dr H. Smith, *Associate*, has received special promotion to the grade of Senior Principal Scientific Officer, for his work at the Microbiological Research Establishment since 1947 on the virulence-enhancing action of mucin and on the chemical basis of the virulence of the anthrax bacillus.

Mr L. Hewgill Smith, *Fellow*, has retired from the position of Chief Chemist to the Hull Branch of the British Oil and Cake Mills Limited. He is now Advisory Chemist to Messrs Couper, Friend & Company Limited, London and Hull.

Dr A. McM. Taylor, *Fellow*, formerly a partner in the practice of Parry & Ferguson, analytical and consulting chemists, has been appointed Assistant to the Director of Research, The British Food Manufacturing Industries Research Association.

Dr F. J. Wilkins, *Fellow*, has been appointed deputy managing director of Glaxo Laboratories Ltd.

Department of Scientific and Industrial Research Act, 1956.—Included in the composition of the new D.S.I.R. Council are Sir Harry Jephcott, *Fellow*, Chairman, and Professor H. W. Melville, F.R.S., *Fellow*, Secretary.

Retirements

Professor R. H. Hopkins, *Fellow*, retired from the Adrian Brown chair of malting and applied biochemistry in the University of Birmingham on 30 September.

Mr J. E. Jones, *Fellow*, of Derby, will retire on 31 December after more than 38 years' service with British Celanese Ltd.

SECTION ACTIVITIES

BIRMINGHAM AND MIDLANDS

Rockets and the Upper Atmosphere. At a meeting at which the Section were the guests of the Wolverhampton Society of Applied Science, Dr P. Reasbeck, of the Department of Physics of the University of Birmingham, gave a paper on "Rocket Exploration of the Upper Atmosphere."

The manner in which Dr Reasbeck became involved in this project was interesting. He, as a chemist, was working on gas phase chromatography, and when American scientists in 1949 were investigating the possible change in composition of the atmosphere, it was to the University of Birmingham that they turned for analysis involving the estimation of helium in amounts down to 10^{-9}cc with an error of only 1/2 per cent. Samples of air were collected up to a height of 110 miles in the nose of the rockets and on analysis there appeared to be enrichment of lighter gases in the samples from greater altitudes. It was subsequently found that the sampling methods were at fault in that at the high velocity at which the samples were taken, shock waves were formed across the intake tube and some mass discrimination took place. Subsequent work would appear to indicate that the Law of Partial Pressures is maintained throughout the earth's atmosphere and that there is no gravitational separation.

Dr Reasbeck surveyed the history of atmospheric exploration and commented on the sampling of air from mountain tops, from balloons and by the more recent rocket techniques. An excellent film of the launching of the American

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Viking rockets was shown. These have been developed from captured German V2 appliances, and, though having possibly smaller range, are better suited economically to scientific research, reaching heights of 70-100 miles, compared with the 250 miles attainable with two-stage V2 rockets.

The reasons for this research were discussed, including the basic necessity for knowing the constitution of the atmosphere. A layer with high ozone and carbon dioxide content was found at 22 km. This possibly controlled the heat of the earth's surface and maintained an energy balance. High winds, of the order of 200 m.p.h., were found at 70-90 km, and these are thought to be connected with the heating effect. Ionised regions have been found at 100, 200, and 250 km.

Investigations which have been carried out with rockets, apart from temperature and density variation, have included a scanning of the solar spectrum down to 10 Å. A solar spectrograph was flown in the nose case, and results were telemetered back to the ground. The spectral energy was less than that theoretically predicted, and the possible presence of relatively cool hydrogen was indicated. No evidence was found to support the view that the atmosphere filters out low energy cosmic radiation. No radiation with energy less than 1 beV was found at high altitude.

Reference was made to the fact that the American rocket research was planned to be extended during the geophysical year 1957, but that Britain's share in the project was limited to the analysis of gases.

BRISTOL AND DISTRICT

Social Evening and Film Show. This meeting on 25 October held at the Technical College, Cheltenham, was arranged by Dr M. E. Foss, the North Gloucestershire representative. After the films "Chromatography" and "The Refining of Precious Metals," there was a short break for refreshments, which was followed by a discussion on Section affairs, notably lectures and possible summer outings. The District Member of Council, Mr B. W. Minifie, gave a short talk on Institute matters.

High Polymers. The Tilden Lecture on 1 November, delivered by Professor G. Gee, F.R.S., on "Physical Properties of High Polymers in relation to their Chemical Structure," proved extremely popular. The Chair was taken at this joint meeting by Professor D. H. Everett, F.R.S.

Social Evening. At this meeting, held in the Senior Common Room, University of Bristol, on 15 November, the Committee this year decided to devote the whole evening to discussion of Institute affairs both local and general. This decision, taken because discussion had been seriously curtailed the previous year by lack of time, was amply justified. Members present commented on lecture programmes, summer outings, the *Journal*, New Regulations, new subscriptions and many other controversial topics and generally made full use of this golden opportunity. Messrs Minifie and Moore, who were present, gave the Council viewpoints, and a number of students also took part in the discussion. Dr R. W. Bolland gave members a brief report on the recent Conference on The Education and Training of the Chemist which he had attended, and the meeting closed with the Chairman, Dr P. F. Tiley, reading his own composition, entitled "The Martian Chemist."

CUMBERLAND AND DISTRICT

Agricultural Pesticides. The Section was both entertained and instructed on 19 October when Dr E. F. Edson, of Fisons Pest Control Limited, presented a paper on "The Toxicology of Agricultural Pesticides."

In this well illustrated talk, the many applications of chemicals to pest and weed control were described, and the conditions under which they are used were outlined. In illustrating the importance of these materials to agriculture, Dr Edson said that in England four million acres of produce were sprayed out of a possible twelve million, and in some areas, such as East Anglia, 75 per cent of sprayable crops were treated.

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The toxic hazard to man, cattle and neighbouring crops, soil microflora, insects and even fish was carefully studied before a pesticide or herbicide was marketed. Dr Edson briefly illustrated the effects of some of the well known agents, such as D.N.O.C., sodium arsenite, chloromethyl urea and the organo-phosphorus compounds, and described the precautions to be taken when using the more toxic of these materials.

The lecture was of value, not only to the chemist in showing how careful one must be before encouraging the widespread use of chemicals in the biological field, but also to the many enthusiastic gardeners in the audience.

Annual Lecture to Schools. On 2 November Mr E. Atherton, of I.C.I. Ltd., provided the annual lecture to schools, choosing "Colour" as his subject.

The lecture, and the demonstrations which accompanied it, quickly revealed the limitations of the eye as an instrument for either the qualitative or quantitative evaluation of colour. The interdependence of the nature of the light, the object itself and the eye were clearly demonstrated. Articles which appeared drab in the yellow light of sodium were shown in their true colours in daylight. The selective qualities of the eye and the effect of fatigue were adequately shown. An excellent film on colour completed the meeting, which was attended by a full audience of senior scholars.

The lecture was repeated in the evening to a large audience of Section members and visitors. On this occasion Mr Atherton expanded his talk to include a more theoretical treatment of the subject. The importance of the scientific approach to colour and its evaluation as it affects the dyeing industry are emphasised.

Mr J. H. Tonkin took the Chair at the afternoon meeting and Mr K. Saddington presided over the evening lecture, when Mr E. Kemp proposed the vote of thanks to Mr Atherton and his assistants.

DUNDEE AND DISTRICT

Proteins and Plastics. Professor J. B. Speakman, Professor of Textile Industries, University of Leeds, had as his subject "Proteins and Plastics" when he gave the opening lecture of the Winter Session in the Chemistry Lecture Theatre, Queen's College, Dundee, on 26 October, the Chairman being Dr T. J. Morrison.

Professor Speakman opened his lecture by emphasising the impact of the newer synthetic fibres on the woollen industry. He showed the importance of the woollen manufacturers' assessment of the 'character' of a wool, 2,000 varieties being distinguished by hand and eye. Recent work has, however, been able to explain some of the aspects of 'character.'

Engineers are helping the woollen industry to compete with the newer fibres. For example a revolution in the manufacture of woollen yarn has been brought about by a simple device, the invention of Air Vice Marshal Ambler, by which the number of operations required to produce the yarn has been considerably reduced.

The chemist, too, has played his part in (*a*) preventing shrinking, (*b*) making wool indigestible to moth grubs, (*c*) in enhancing the wearing properties of woollen socks and (*d*) in enabling worsted materials to retain pleats, this last discovery having been made 18 years ago.

Professor Speakman then showed how neatly the woollen industry could make a woollen fur coat, but he was unable to quote the price.

Summing up, the speaker said that the woollen industry was an interesting one and demanded ingenuity both from the chemist and the engineer.

The lecture was delivered in an interesting and entertaining manner which provoked some lively discussion. Mr H. P. Parsons proposed a vote of thanks and commended the speaker on such a stimulating lecture.

EAST MIDLANDS

Twenty-first Anniversary Evening. A spirit of gaiety heralded 28 September, when members of the East Midlands Section, their ladies and friends, numbering some 140 in all, celebrated the 21st Anniversary of the Section's foundation.

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Derby, the birth-place of the Section, was the appropriate scene of the festivities, where an admirable evening's entertainment had been arranged by the Derby members of the Committee, under the leadership of the Chairman, Mr R. Betteridge, at the Assembly Rooms. Here, members were welcomed by Dr G. M. Dyson (first Chairman of the Section) and Mrs Dyson.

The evening's activities were very varied and provided satisfaction for widely differing tastes, including dancing, a mannequin parade, a buffet supper and, for the more seriously minded, an exhibition illustrating progress made by the chemical industries of the East Midlands during the past decade or two. Exhibits included: 'Textbooks Old and New,' and 'Macro laboratory methods contrasted with semi-micro methods' (provided by Derby Technical College); 'Stages in the Production of the Corticosterols' (by Boots Ltd., Nottingham); 'Modern Glassware' (Loughborough Glass Co. Ltd.); 'Synthetic Fibres, Fabrics and Plastics' and 'Products obtained from the Cracking Process' (by British Celanese Ltd., Derby); 'Man-made fibres and their Finished Products' (by W. &. E. Saxby Ltd, Nottingham).

Undoubtedly the highlight of the evening was the Mannequin Parade, arranged by British Celanese Ltd. and beautifully staged in the ballroom, with appropriate soft lights and sweet music. The womenfolk were delighted to see creations by famous *hautes couturiers*, modelled by some very attractive and accomplished employees from the Celanese factory at Spondon. One suspects that the male interest, supposedly concerned with the newest 'Celanese' fibres from which the gowns were made, extended beyond this, and that the names Elizabeth, Patricia, Dorothy, Ann, Sheila, Brenda, Pat and Margaret will linger long in the memories of many of those present. The collection included a bewildering array of day dresses, evening gowns and ensembles, sports dresses and novelty clothes.

After the mannequin parade, Mr Betteridge then called Dr F. W. Gibbs to the stage, who, with Mrs Gibbs, had honoured the Section with their company, in representing the Institute. Then followed those founder-members of the Committee (all past Chairmen) who were present, namely George Malcolm Dyson; Harold Haydon Barber; Frederick Cecil Bullock; Ronald Davidson; George Frederick Hall; Louis Hunter and Charles William North. Other past Chairmen, Samuel Walter Atherley, Leonard Powell Priestley and Charles Frederick Ward, were asked to join them.

Dr Dyson then gave brief reminiscences, in his characteristic style, of the early days of the Section. Dr Gibbs, on behalf of Headquarters, congratulated the Section on its growth and virility; and Professor Hunter gave tribute to all those who had been instrumental in making the arrangements for, and had participated in, the evening's entertainment.

The company then adjourned for a satisfying supper and afterwards returned to continue dancing until midnight. The dancing was enlivened by distribution of 'spot' prizes to certain lucky recipients, and the final episode to a memorable evening was provided by Dalmas & Co. Ltd., of Leicester, who presented each guest with a box of surgical dressings on leaving the Assembly Rooms.

Chemistry at the Brewing Industry Research Foundation. The first lecture evening of the season was held on 25 October, at the Leicester College of Technology and Commerce, when Dr A. H. Cook, F.R.S., Assistant Director of the Brewing Industry Research Foundation, gave a lecture on "Chemistry at the Research Foundation."

Dr Cook explained that the purpose of the Foundation is broadly to further the technical efficiency of the industry by a comprehensive study of brewing materials, such as malt, hops and yeast, and of brewing processes. At each point this general enquiry involves chemical investigation, much of which has a significance far beyond the narrow confines of brewing itself.

For instance, an adequate assessment of the malting behaviour of barley includes a remarkable range of research into carbohydrate chemistry and the related enzymology. This in turn embraces chemical aspects of the dormancy of resting cells and of their ultimate germination. Foremost in the study of hops is the chemical nature of the bittering and preservative principles and of

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the constituents conferring desirable aroma on the beer. Their efficient use, their biogenesis and the incidence of disease in the hop plant are among many other topics calling for chemical research. As to the study of yeast, purely enzymic studies, sporulation, hybridisation, the mechanism of flocculation and the control of the general character of the yeast are only a few of the many points on which chemical research of the most varied nature is required. It will be seen that this wide spectrum of investigation encompasses a field which is probably for the first time receiving co-ordinated and integrated attention within a single scientific research centre.

The lecture was followed by a lively discussion, at the end of which Dr A. G. Catchpole, who had presided in the unavoidable absence of the Chairman, Mr R. Betteridge, called upon Professor L. Hunter to express the thanks of all present to Dr Cook for a fascinating, stimulating and informative lecture.

EDINBURGH AND EAST OF SCOTLAND

Triterpene Chemistry. The first lecture of the new session was delivered on 18 October by Professor F. S. Spring, F.R.S., who dealt with the chemistry of the tetracyclic tripenoids. The biogenesis of this class of compounds was discussed and their chemistry illustrated by reference to lanostenol, euphol and *cyclo*artenol. Professor Spring then outlined his recent investigations leading to the elucidation of another member of this class, butyrospermol.

The Chairman of the Section, Mr Louis Fletcher, then invited questions, and an interesting discussion ensued in which prominence was given to recent syntheses in this field and to physical methods of analysis and separation. The Section's warm thanks were voiced by Dr G. O. Aspinall.

Committee Meeting. The Committee met under the Chairmanship of Mr Louis Fletcher on 25 September to conduct the normal business of the Section. In addition, facilities for part-time study directed towards the Graduate Membership examination in the Section Area were reviewed in detail. Comments are invited on this topic; they should be addressed to Dr E. S. Stern, J. F. Macfarlan & Co., Ltd., Abbeyhill, Edinburgh 8.

LEEDS AREA

A Joint Meeting of the Section with the Leeds University Chemical Society was held at the University of Leeds on 25 October, Mr A. C. Francis, Chairman of the Section, presiding. After a film display and a social interval, Professor W. Bradley lectured on "New Developments in the Chemistry and Applications of Dyestuffs."

Starting from the empirical discoveries of Perkin and Hofmann and the synthetic work that became possible when Kekulé had introduced the concept of the benzene ring and Liebermann had shown the connection between colour and unsaturation, Professor Bradley passed to such modern problems as improvements in the fastness of well-known types of dyestuffs, the special difficulties presented by acetate rayon and synthetic fibres, and the ingenuity displayed in devising methods of dyeing glass, metals and crystals. The large audience was fascinated by the clarity and simplicity with which these subjects were handled.

In the course of the subsequent discussion it was explained that woven glass fabric had the advantage of being fireproof and that while dyestuffs on glass, being surface-held, could be removed by abrasion, they were fast to rubbing. The faint dyeing of crystalline products, such as ammonium nitrate, was often useful in preventing the crystals from running together in storage. For use in water-colour painting pigments were preferable to dyes, because the latter, if not homogeneous, would separate by a process akin to paper chromatography.

A vote of thanks was proposed by Mr A. Thomson, who described the lecture as crystal-clear, colourful and deceptively simple. It was seconded by Mr S. Hirst, of the University Chemical Society and carried with acclamation.

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LIVERPOOL AND NORTH-WESTERN

Third Dimension in Chemistry. There were over a hundred present at a Section meeting on 8 November at the University of Liverpool. The Chairman, Mr C. K. Boundy, introduced the lecturer, Dr A. F. Wells of the Research Laboratories, I.C.I., Ltd. (Dyestuffs Division), who a few years ago lectured to the Section at Preston. Dr Wells is the author of *Structural Inorganic Chemistry* and *The Third Dimension in Chemistry*, which was also the title of his talk to the meeting.

Dr Wells prefaced his subject with a few words on crystallography. He then proceeded to explain a number of crystal types by means of lantern slides, molecular models and blackboard diagrams. He demonstrated how chains or lattice network could be superimposed in layers to produce various crystal structures. He described the topological features of a few of these, namely, diamond, ice and phosphorus pentoxide, and outlined their different symmetries. He sketched the structures of types of molecules containing atoms having from two to twelve linkages. For example, oxygen with 2 linkages produces either chains or rings, atoms with 3 and 4 linkages give 'connected networks,' 6 give 'open packings' of polyhedra, 8 'space filling' by polyhedra, and 12 'close packed' structures. The speaker showed numerous examples of three-dimensional extended networks, such as nylon and polypeptides, and concluded with some other structures, not properly understood, known as 'interpenetrating frameworks.' In spite of the geometrical nature of his subject, Dr Wells succeeded very ably in holding the interest of his audience.

A discussion followed in which Messrs H. Houghton, T. L. Bowyer, H. H. Bland, H. R. Jones and D. G. Cooper participated. The discussion revealed that the study of most of these structures had been made more for the interest of the problems involved than for any immediate practical value. A vote of thanks to Dr Wells was proposed by Mr H. R. Jones.

LONDON

Newer Analytical Reagents. Mr L. M. Miall presided at the joint meeting with the South East Essex Technical College Scientific Society which was held at the College on 23 October.

The speaker, Dr R. Belcher, said that in the field of primary standards, bisethylenediamine sulphatocerate has been proposed as a replacement for ceric sulphate. It is claimed by Singh to have the necessary properties for use as a primary standard; it remains unchanged over a period of years and has a very favourable conversion factor. While it has a low solubility in water, it can be used satisfactorily at a strength of N/50 and it is very possible that it will replace dichromate completely.

There has been no recent outstanding development in indicators, either in the acid-base or redox range, but Hungarian workers have described chemiluminescent indicators, which emit light at the endpoint. The application of these materials is not however obvious.

There have been many new compounds suggested recently as precipitation reagents, and some of these are likely to be of more than passing interest. 1:2:3-Benztriazole, which has been used for some time for the determination of nickel in cast iron, is now claimed to be virtually specific for silver, in the presence of E.D.T.A., and the name 'Silvon' has been suggested for it. Banks and Hooker, who have studied dioximes, have put forward a methyl*cyclo*hexanedione dioxime as an improvement on dimethylglyoxime. The reagent is soluble in water and the precipitated nickel complex filters rapidly and is easily washed.

2-(*o*-Hydroxyphenyl) benzoxazole has been used for the selective determination of cadmium, and Burn and Robertson have studied the precipitation of the copper complex of this reagent in the presence of E.D.T.A. at pH 11. These workers have also investigated the determination of nickel by dimethylglyoxime and have eliminated interference when cobalt and iron are present together by the use of "Versene Fe specific"—N:N'-dihydroxyethyl glycine.

The use of *p*-chloro-*p*'-aminodiphenyl (CAD) for the determination of sulphate has the great advantage over barium chloride of giving an immediate precipitate

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even at low concentrations and is not subject to interference from nitrate. It is very useful in the turbidimetric estimation of traces of sulphate.

Dr Belcher mentioned several other reagents which showed promise but pointed out that in many instances it was still too early to decide which of them would eventually come into general use. In the discussion which followed, nine speakers took part, and it was evident from their remarks that the demand for new analytical reagents will never cease.

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Chromatography. A meeting was held at Kingston Technical College on 1 November when Mr F. C. Hymas was in the Chair. He introduced Dr Tudor S. G. Jones and asked him to deliver his lecture on "Chromatography." The lecture has previously been reported in the *Journal*, for it has proved very popular with London Section audiences and this occasion was no exception to the rule. Several members of the large audience joined in discussion with Dr Jones, and the evening concluded with a vote of thanks to the speaker proposed by Mr N. Lindop.

Annual Dinner Dance. This year's Dinner Dance, held on 2 November, was a notable function in several respects, and it was the first to be held at a new venue, St Ermin's Hotel. Again, the after-dinner speeches were models of brevity, and the function was a complete success in every sense of the word; it was over-subscribed and some late applications for tickets had most regretfully to be refused.

This year the principal guest was Sir Charles Dodds, M.V.O., F.R.S., Chairman of the London Section, Society of Chemical Industry, who, replying to the toast of "The Guests," paid tribute to the close ties of affection between the two Societies. Our President, Dr D. W. Kent Jones, who replied to the toast of "The Institute," thanked the Section for an opportunity to speak in a lighter mood. The Section Chairman, Mr Miall, reminded members' ladies that an additional function was planned for them on 13 February, 1957, at which some of the secrets behind the glamour of nylon and other man-made fibres might be revealed.

The excellent setting and arrangements for the evening were greatly appreciated by all who attended, and the only criticism that could be offered was that in the more popular dance numbers the floor became somewhat overcrowded. But as this was in no small measure due to the almost unexpectedly large number present, it is hardly a valid criticism and is a welcome reminder of the increasing interest that is being taken nowadays in Section affairs. The Social Activities Committee certainly are to be congratulated on their most successful arrangements.

Laboratory Technique in Radiochemistry. Radiochemical techniques have already proved valuable in connection with the rapid separation and estimation of many elements on the semi-micro and microchemical scale and in many other applications. Under the Chairmanship of Dr C. C. Hall a crowded audience at Norwood Polytechnic on 5 November heard Dr E. N. Jenkins give an up-to-date review of the position.

Owing to the harmful effects of the radiations emitted by radioactive materials their use required special laboratory techniques to provide the necessary protection. The major hazard varies. With most alpha emitters contamination is most to be avoided, while protection against the radiation is effected even by paper and glass, as the radiation is not penetrating. With beta emitters special precautions against contamination are still required, but as the radiation is rather more penetrating, shielding with aluminium, perspex or glass is required. Gamma radiation, which is usually associated with beta radiation, is still more penetrating, and lead shielding is required.

The amount of shielding depends not only on the type of radiation but also on the quantity of material involved. The shielding and the type of laboratory required for work with different quantities of radiation was discussed in the light of the maximum permissible dosage of radiation.

The design, equipment and auxiliary services of a laboratory for handling 10–1000 millicuries of radioactive material are vastly more elaborate than those

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required for work with 0·01–1 millicurie, which can be used with the minimum of alteration of a chemical laboratory.

When using high-level activity, elaborate and costly air-conditioning with air filtration and monitoring facilities are required. In the laboratories at Harwell, which were probably the first permanent ones of this type to be built, a service of 'health visitors' and close medical supervision of personnel are provided. Laboratories for handling even larger quantities of radioactive materials were mentioned.

Some of the techniques which have proved particularly valuable in this field, such as ion exchange techniques, paper chromatography and gamma-scintillation spectrometry, were briefly discussed.

Annual General Meeting. The Annual General Meeting was held at the Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, on 14 November when the retiring Chairman, Mr L. M. Miall, presided.

The following Officers were elected: Chairman, C. C. Hall; Vice-Chairmen, F. C. Hymas, C. Simons; Hon. Treasurer, P. F. Corbett; Hon. Secretary, A. J. Turnbull; Hon. Assistant Secretary, H. Holness.

The Chairman announced that as a result of the postal ballot the following had been elected to serve on the Section Committee for the next three years: Miss E. I. Beeching, Messrs H. J. Barber, V. S. Griffiths, W. A. Johnson, M. A. Phillips, J. H. Pryor. Messrs J. R. Barr, D. T. R. Hollis, W. M. Lewis, A. M. Maiden, W. D. Maniece, K. G. A. Pankhurst, P. A. Raine, J. E. Salmon, A. H. Thorneloe and B. C. L. Weedon constitute the remainder of the Committee whose term of office has not yet expired. Mr L. M. Miall is an *ex-officio* member of the Committee.

Messrs G. H. Edwards and H. G. Smith were elected Hon. Auditors and Messrs L. M. Miall and J. H. Skellon continue as District Members of the Council until April 1957.

The Hon. Almoner, Mr D. M. Freeland, then gave his annual report on the Benevolent Fund, and the Chairman drew attention to the value of Group Subscriptions, which had contributed £131 to the fund in the past two years. Votes of thanks to retiring officers and members of the Committee were passed, and the Chairman in his reply pointed out that the retiring Hon. Treasurer had served in that capacity for five years.

The meeting was then opened for general discussion and a number of members took this opportunity of commenting on Institute affairs in general. Among these were Dr H. J. Barber who referred in strong terms to the recent special General Meeting of the Institute and in particular to Resolution 2 which had been passed there. He said that there was an uneasiness about the implications of the proxy rule and enquired whether it would be proper for this meeting, if it thought fit, to draw Council's attention to the situation. Some discussion followed on the legality or desirability of forming resolutions under 'any other business' at a Section A.G.M., but several members thought that more facilities should be provided for discussion of general Institute affairs at ordinary Section meetings. After a number of members, including some past officers of the Section, had stated their points of view, Mr K. D. Hunt said that the attention of the Committee had now been drawn to the many points raised in the discussion and proposed that the matter thereafter be left to the Committee. The meeting concurred with this proposal, and the Chairman said that consideration would be given to the discussion at the December meeting of the Committee. He concluded by expressing satisfaction at the lively discussion which had taken place.

At the conclusion of the business meeting, Dr C. C. Hall took the Chair and three films were shown. "The Titanium Pigment Story," a film which tells of the development of this modern pigment, was followed by "Moving Spirit," a cartoon which added light relief in tracing the development of wheeled transport from the dimmest ages through the early mechanical days to those of modern internal combustion engines. Finally, "The Story of Palomar" showed the stages and difficulties in the production and polishing of the reflector for this great observatory. The difficulties were by no means ended when the reflector

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was produced, for the methods adopted for its safe transport up the mountain to the Observatory are a story in themselves.

Buffet Dance, 1956. This annual event, held jointly with the London Section, Society of Chemical Industry, will take place at Caxton Hall on Thursday, 28 February, at 7.30 p.m.

MANCHESTER AND DISTRICT

Exhibition of Laboratory Apparatus. The Annual Exhibition of laboratory apparatus and techniques will be held at the College of Science and Technology, Sackville Street, Manchester, on 3 January and 4 January, 1957. The exhibition will be in rooms E1 and E19 and will be open to the public from 2 p.m. to 8 p.m. on 3 January, and from 10 a.m. to 8 p.m. on 4 January.

Annual General Meeting. The 38th Annual General Meeting will be held at 6.15 p.m. on Friday, 4 January in room E8 of the College of Science and Technology, Manchester.

MID-SOUTHERN COUNTIES

Use of Radio-Isotopes in Industry. On 11 October, the first meeting of the winter season was held jointly with the Poole Technical Group at Poole Generating Station by permission of the authorities. The speaker was Dr R. Roberts (A.E.R.E., Harwell). After discussing the production of electrical power from nuclear reactors, the speaker showed that enormous quantities of radioactive fission products are formed, for example, the production of 20,000 MW of electricity results in the annual production of 10^9 c of fission products.

The uses of some of these fission products, more especially those of long half-life, *e.g.* ^{137}Cs and ^{90}Sr, were outlined. Then uses in radiation therapy, sterilisation and pasteurisation of foods, sterilisation of heat-labile drugs and finally insect control were shown. Interesting developments in the field of mutation in the agricultural and medical sciences were discussed.

Chemical application in the field of irradiation analysis with particular reference to polymerisation were dealt with. The lecture was well illustrated with slides and terminated after a lively discussion.

Atomic Power. On 16 October, a further joint meeting was held with the Poole Technical Group at the Poole Generating Station, the speaker being Dr J. K. Dawson (A.E.R.E., Harwell).

After a discussion on the reactions taking place in nuclear reactors, the economics of nuclear power generation were discussed. Allowing for the plutonium produced, the cost of nuclear electricity becomes competitive with that from conventional sources. One of the chief advantages of nuclear power production is the release of more and more coal for chemical purposes.

The construction of the reactors was then outlined, particular reference being made to difficulties experienced in the heat-exchanging systems. The use of nitrogen gas as coolant results in the production of nitric acid.

Mechanical distortion of the uranium elements and interference from fission products help to reduce the efficiency of the reactor. The aqueous fuel reactor was then discussed. This type of reactor has several advantages, *e.g.* the removal of ^{135}Xe, and the conversion of ^{232}Th to ^{233}U, which is not possible in the gas-cooled reactor.

The lecture was terminated by descriptions of other types of reactors. Slides were shown throughout the talk and after a lively discussion the meeting closed.

Steric Hindrance in Analytical Chemistry. On 19 October a joint meeting was held with the University of Southampton Chemical Society and the Chemical Society at the University of Southampton. The speaker was Dr H. M. Irving, of the University of Oxford.

After a brief account of steric effects in co-ordination compounds and an indication of thermodynamical methods for expressing stabilities of complexes, the speaker went on to discuss the behaviour of various metals towards 8-hydroxyquinoline (oxine) and 2-methyl-8-hydroxyquinoline, with particular reference to the stereochemistry of the complexes so formed.

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Variations in the character of precipitates by varying the molecular structure of the reagents were discussed, and it was shown that the introduction of a methyl group in the 2-position of oxine prevented reaction with aluminium. Apparently this phenomenon is unconnected with the size of the metal ion; the reason put forward is that because of structural effects the precipitation of aluminium with 2-methyl-8-hydroxyquinoline commences at a higher pH than with oxine, but at this pH the tartrate buffer present holds up the aluminium.

A discussion on the complexing ability of various metals and solubilities of the complexes, which are one measure of the sensitivity of reaction, showed that there was no correlation between these factors, but it was clear that steric effects were real and did affect the stability of the complexes.

The lecture was illustrated with slides.

Chemistry in Your Garden. On 23 October a meeting was held at the Cathedral Hotel, Salisbury. The speaker was Dr R. Stewart of Fisons, Ltd. The breakdown of rocks into clays, with reference to the chemical and physical natures of the latter, was discussed. The importance of humus and of the essential and trace elements was shown, with particular reference to the symptoms exhibited where a deficiency of one or more of these elements is present. These dificiencies were clearly illustrated by colour slides. The subject of fertilisers was also discussed and an interesting account given of soil conditioners. Krilium (the sodium salt of hydrolysed polyacrylonitrile) acts in the same way as humus, namely by aggregating the soil particles and improving the physical nature of the soil. However, its use is limited by its price. The interesting part played by growth regulators was discussed, one particularly fascintating compound being maleic hydrazide, which when sprayed on grass will prevent it growing.

The lecture ended with an account of the various types of weed-killers. A lively discussion followed.

The Extraction and Refining of the Precious Metals. On 25 October, a joint meeting with the Portsmouth and District Chemical Society was held at the College of Technology, Portsmouth. The speakers were Messrs A. R. Raper and F. S. Clements of The Mond Nickel Company.

Mr Raper dealt with the extraction and refining of the precious metals from Canadian ores and produced some rather surprising statistics. The natural concentration of the precious metals is roughly one part per million, and from an annual production of 14½ million tons the final yield of precious metals is 350,000 oz and of silver 1,000,000 oz.

The process of extraction was fully described; it includes magnetic separation, flotation and bessemerising to give crude nickel, which is then purified electrolytically. The anode slimes are worked up for the precious metals, and residues from the carbonyl process for nickel, this process being admirably illustrated by a sound-colour film.

Mr Clements then discussed in some detail the nature of some of the reactions involved in the above separations. A description of the methods of control analysis was given. Spectrographic analysis plays an important part in this work. The ultimate tests of purity are electrical.

The audience were amazed to hear that the loss of precious metals during the very complicated extraction is only 0·1 per cent.

After questions, the meeting closed with a vote of thanks given by Mr N. Bailey.

Works Visit. On 7 November a party visited the Pirelli General Cable Works, Ltd., at Eastleigh. The visit was most interesting. The party was divided into groups, who were given a most interesting tour, which included the copper rolling mill, the wire drawing section, the paper lapping mill, where the copper wire is covered with paper insulator, the armouring section and the oil filling section. The laboratories were also inspected; here various tests are performed, including spectroscopic, mechanical and electrical methods.

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NEWCASTLE AND NORTH-EAST COAST

Organic Chemistry in Retrospect and Prospect. The first meeting of the 1956-1957 session was held on 17 October, at King's College, with Dr J. O. Harris in the Chair. Sir Ian Heilbron addressed the meeting on "Organic Chemistry in Retrospect and Prospect," contrasting the easy prosperity of this country at the turn of the century with its lack of scientific foresight and tracing a fascinating picture of the advances in both scientific and technical organic chemistry since that time. Not the least appreciated feature of his lecture was his wittily phrased reminiscences of his own experiences with the great chemists of the period. The thanks of the very large audience were expressed by Professor J. Baddiley.

NORTH LANCASHIRE

Fluorocarbon Polymers. The first meeting ever in Blackpool was held on 1 November, when Mr E. M. Elliott, I.C.I., Ltd. (Plastics Division), spoke on "Fluorocarbon Polymer Technology." The lecture was devoted almost entirely to polytetrafluoroethylene and the way in which useful articles are produced from the polymer. After listing the properties which help to justify the title of 'noble' plastic, Mr Elliott described how the various forms of the polymer —granulated, coagulated or dispersed—were processed. He ended by referring to the many ways in which the material was used in industry and stressing the variety of its functions. The speaker was warmly thanked by Mr W. H. Roscoe, and the audience, who had an opportunity of examining a large number of samples, clearly appreciated the technological approach to the subject.

Man-Made Fibres. On 14 November, at Blackburn, Mr F. V. Davis spoke on "Man-Made Fibres." He touched on many aspects of the subject, ensuring that there was something of interest for all whether their interests lay in chemistry, textiles, dyeing or finishing, or were non-technical. He began with a brief historical review and then discussed the structure of fibres and the need to strike a balance in their properties. This was followed by a classification of the various polymers —Nylon, Terylene, Orlon, Polythene, Teflon and other special-purpose fibres— and an explanation of the way in which certain characteristic properties associated with high-molecular-weight compounds based on the CH_2 group could be modified. Mr Davis then spoke of the uses of synthetic fibres and indicated their limitations. Lastly he turned to the problems of dyeing and finishing and gave many examples from his own experiences. After numerous questions had been answered, Dr V. G. Jolly proposed a hearty vote of thanks to Mr Davis. The meeting ended with many members of the large audience examining a variety of samples displayed as illustrations of points made during the lecture.

SOUTH WALES

Scientific Glassware Manufacture. A very successful meeting was held on 30 October, at University College, Swansea, when an audience of over 100 members and friends gathered for a lecture-demonstration of the Art of Scientific Glassware Manufacture, given by Mr R. W. Ingamells, of Messrs. H. J. Elliott Ltd., E-Mil Glassworks, Treforest, assisted by a glassblower, Mr E. Turner. Various glass-blowing operations were first described and demonstrated, including the drawing of a piece of wide glass-tubing, various methods of cutting glass-tubing, the making of a cylinder with a foot, making a T-piece and finally the making of a spiral of glass-tubing. Mr Ingamells then described the manufacture of graduated glass apparatus, such as flasks and pipettes, emphasising that exactness in the preliminary gauging of the capacity was all-important. He then described the making of thermometers, with the techniques of filling them with mercury and graduating them, and of hydrometers. The interest aroused was shown by the number of questions put to the lecturer and his assistant, and the thanks of the meeting were expressed by Dr A. R. Lowe. Dr Islwyn Jones presided.

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SOUTH-WESTERN COUNTIES

Symposium on Careers in Chemistry

The 1956-57 Session opened with a Symposium held in the Technical College, Plymouth, on Saturday, 6 October. The subject, "Careers in Chemistry," was discussed from the point of view of the chemist in industry by Dr J. W. Barrett, a director of Monsanto Chemicals Ltd., of the academic and research chemist by Professor H. T. S. Britton of the University of Exeter, of the chemist in the Scientific Civil Service by Dr J. Idris Jones of the Chemical Research Laboratory, D.S.I.R., Teddington, and from that of the teacher by Mr A. C. Truman, formerly senior Science Master and now Deputy Headmaster of the Devonport High School for Boys.

Dr F. D. M. Hocking, Chairman of the Section, presided.

The Industrial Chemist. Dr Barrett stated that, of the 60 per cent of all chemists in industrial employment, half were strictly engaged in the chemical industry; the latter were employed as follows: research, 36 per cent; development, 12 per cent; production, 31 per cent; administration, 9 per cent; sales, 7 per cent; miscellaneous, 5 per cent.

Dealing with salaries, the speaker quoted statistics from the Remuneration Survey (*J.*, Sept., 518) to support his contention that chemists in industry received, at all ages, somewhat higher salaries than chemists otherwise employed. It was stressed that the chemical industry was based on scientific thought and endeavour. Entry to the industry may be through a particular department or through management training schemes. The popularity of research commonly resulted in entry via the research department.

With chemical processes increasingly controlled by engineering and exact science there were more openings in production for the engineer and the physicist. Development presented challenging opportunities to men with knowledge of a company, its processes and ramifications. In regard to sales, the speaker stated that chemical compounds that could be defined were easier to sell; certain plastics, on the other hand, were less easily defined, though their physical properties may be capable of definition.

In general, said Dr Barrett, careers in industry would depend on the general success of the industry. If costs were to rise through increases in labour and technical costs it would become essential to produce more and to produce more cheaply. It should also be remembered that since technical processes could be purchased firms did not necessarily need long research programmes.

When considering industrial relationships, Dr Barrett emphasised the need for tolerance of the other sides of industry and for the application of knowledge possessed by other sides of industry. It was part of the chemist's duty to show other sides of industry how to apply this knowledge. He stressed the need for simplicity of expression in giving information to people of wide skill but little knowledge of chemistry. Above all he pressed for recognition of industrial chemistry as an exact science.

University Teaching and Research. Professor Britton deplored the movement of so many chemists into industry and away from all forms of teaching. Schools, particularly girls' and to some extent boys', were being denuded of teachers. In time, he forecast, the universities would be deprived of students and there would inevitably be repercussions on industry.

Professor Britton referred to the lack of guidance obtainable from G.C.E. Advanced Level results as a means of deciding on a student's capacity to embark on a particular course of study.

The Scientific Civil Service. Dr J. Idris Jones outlined the structure of the Service and the functions of the main groups of officer, thus: Scientific Officers were the directing and inventive 'brains' and were supported by Experimental Officers. The former were recuited from graduates, preferably with post-graduate training; the latter were less well qualified (*e.g.* H.N.C.) and, while possibly capable of taking responsibility, their main task was to relieve the Scientific Officers of routine work. The third group within the Service, Assistants (Scientific), were expected to possess G.C.E., preferably with credit in mathematics.

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The nationalised industries, the British Broadcasting Corporation, the U.K. Atomic Energy Authority, and the Medical and Agricultural Research Councils were outside the framework of the Service; they interviewed and appointed their own candidates.

As there were over 100 research establishments in the country it was possible to some extent to meet the specialised interests of a candidate regarding type and place of work. The main employing department was the Ministry of Supply, and chemists were employed by it in the analytical branch, the inspectorate and other posts. The Royal Naval Scientific Service, in conjunction with the Ministry of Supply, carried out research on mines, torpedoes and anti-submarine devices. An officer appointed to this branch could be required to serve, for a period, at sea or abroad. Work for the chemist employed by the Ministry of Agriculture may be connected with control of infestation or the testing of insecticides. Other government departments requiring the services of chemists were the Ministry of Fuel and Power, the G.P.O., the Department of the Government Chemist, the Home Office and the Royal Mint. The Department of Scientific and Industrial Research, in its 14 establishments, carried out basic research on problems of national importance, such as corrosion and high polymers and plastics.

In addition, there were a number of Research Associations maintained by the various industries, perhaps the best known of which was the Shirley (Cotton Research) Institute at Manchester; and openings existed also in the Patent Office (Board of Trade).

Dr Idris Jones stated that remuneration compared favourably with that obtainable in industry; he mentioned also the advantages of a 5-day week and the reasonably long holidays granted.

Teaching in the Grammar School. Mr A. C. Truman underlined Professor Britton's remarks by stating that the development of automation would cause still greater demands for technicians and would result in a further decrease in the number of graduates available for teaching appointments. He stressed the fact that, above all, teaching was a vocation.

Dr F. A. Royle proposed a collective vote of thanks to the speakers.

THAMES VALLEY

Inaugural Meeting. The first meeting of the newly formed Thames Valley Section was held at the University of Reading on 13 October. After a short business discussion, in which Dr C. H. Bamford (Maidenhead) was elected Chairman and Drs T. G. Halsall (Oxford), P. F. Holt (Reading), H. M. N. H. Irving (Oxford), W. J. Kramers (A.W.R.E., Aldermaston), E. S. Lane (A.E.R.E., Harwell), D. T. Lewis (A.W.R.E., Aldermaston) and R. N. C. Strain (Farnborough) and Mr J. A. Radley (Reading) were elected to the Committee, the President, Dr D. W. Kent-Jones, delivered a lecture on "Food and Drink."

Dr Kent-Jones emphasised the vital importance of the food problem today and its relation to the enormous yearly increase in the world's population and the continual demand for an improved nutritional level. However, in this country notable advances had been made in the distribution of food to the various classes of the population. No longer were the poorer classes penalised by their small incomes in the ability to provide the necessary food for the family. Interesting statistics were presented, comparing the quantity and nutritive value of food consumed by income groups ranging from £15 to £6 per week, and it was indeed gratifying to observe that all were above the recommendations of the Britsh Medical Council. In spite of the fact that there were still a great number of nutritional problems yet to be investigated, Dr Kent-Jones considered that the chances of the diet consumed by anyone in this country today being insufficient in any respect was very remote. Due to improvements in preservation, storage and methods of transport of food, the townsman was now fed as well as the countryman. Although the quantity and nutritional quality of the food was highly satisfactory, Dr Kent-Jones felt that considerably more attention should be paid to the cooking and presentation of food in this country. Every effort should be made to prepare a meal which was both attractive and appetising. In

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this respect the importance of moderate amounts of carefully chosen drink taken before and with food could not be overestimated.

An instructing and often amusing discussion followed, and the members and guests later adjourned to the Caversham Bridge Hotel where, according to Dr D. T. Lewis, who proposed the vote of thanks, they might put into practice the theoretical principles laid down by the President.

See photograph opp. p. 731.

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NEWS AND NOTES

MEETINGS AND EXHIBITIONS

Aslib Winter Meetings.—Among forthcoming Aslib meetings, which will be held at 6 p.m. at the Royal Society of Arts, 8 John Adam Street, London, W.C.2, are:

30 January	Dr A. R. Michaelis, "The Scientific Film as a Medium of Scientific Communication."
5 March	Dr D. C. Martin, "The Royal Society's Interest in Scientific Publications and Dissemination of Information."
29 March	Mr H. C. Richardson, "Re-classification of the Library of the Institution of Civil Engineers."

Plastics Institute Lecture for Young People.—The Institute's third Lecture for Young People will be given in London on the afternoon of Wednesday, 2 January, 1957, by Mr J. Butler, Development Manager, British Industrial Plastics Limited, and will be entitled **"Plastics and the Engineer."**

The lecture will be delivered in the Hoare Memorial Hall, Church House, Westminster, London, S.W.1, at 2.30 p.m., and will be illustrated by slides and supported by animated models. The Chair will be taken by the President of the Plastics Institute, Mr J. L. Daniels.

Admittance will be by ticket only obtainable free of charge from the Secretary to Council, The Plastics Institute, 6 Mandeville Place, London, W.1.

Children of Plastics Institute members will have a prior claim but a substantial number of tickets will be available for schoolchildren, students, apprentices and works' personnel between the ages of 12 and 20 years. There will be no objection to parents accompanying their children or teachers accompanying a party of schoolchildren, but tickets must be obtained by all those wishing to attend.

Sixth Commonwealth Mining and Metallurgical Congress.—Already nearly 3,000 people from 70 countries have indicated their interest in the Sixth Congress, which is to be held in Canada from 8 September to 9 October, 1957. Fairly complete programme information is expected to be available by January, 1957, and registration must have been completed by 31 January. Enquiries should be addressed to The Executive Secretary to the Congress, 837 West Hastings Street, Vancouver 1, B.C., Canada.

OCCA Ninth Technical Exhibition.—More than 80 firms have made arrangements to exhibit at the 1957 Exhibition of the Oil and Colour Chemists' Association to be held at the Royal Horticultural Society's New Hall, Greycoat and Elverton Streets, London, S.W.1, on 12, 13 and 14 March. As before, the theme will be the presentation of technical advances in those industries supplying the paint, varnish, printing ink, linoleum and other allied industries. There will be no charge for admission, nor for the descriptive brochure regarding the exhibits. Buffet facilities will be available. Further information can be obtained from the General Secretary, Mr R. H. Hamblin, Oil and Colour Chemists' Association, Memorial Hall, Farrington Street, London, E.C.4.

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DUBLIN SYMPOSIUM ON PYRONES

Forty years ago Professor Hugh Ryan published his first paper on flavones from University College, Dublin. Since that time the chemistry of flavonoids has received much attention in Dublin, and it was appropriate that a Symposium on "Recent Advances in the Chemistry of Naturally Occurring Pyrones and Related Compounds" should have been held in 1955 at University College, Dublin, to mark the anniversary of this first flavone paper from the Dublin laboratories. The Symposium, probably the first to be devoted entirely to flavonoids, occurred at a time when the chemistry and biochemistry of these substances is being pursued with renewed vigour after a period of comparative quiescence.

The contributions to this Symposium form the contents of the *Scientific Proceedings of the Royal Dublin Society* for August, 1956, and fall automatically into two main categories, namely, those which summarise our present state of knowledge in certain specialised topics and those which describe hitherto unpublished advances in the field.

The first category includes a summary by T. R. Seshadri of the occurrence of chalkones and flavanones, laying particular emphasis upon possible biogenetical implications, with a complementary contribution concerning the α-pyrones from K. Venkataraman and his colleagues. As is singularly appropriate, T. S. Wheeler (on behalf of the Dublin School) provides a valuable summary of the complex relationships between flavones and aurones, and H. Erdtman gives a comprehensive account of the flavonoid heartwood constituent of conifers, with particular reference to their useful indications of taxonomic relations between various conifers. A comprehensive review of the distribution of the commoner phenolic constituents of plants by E. C. Bate-Smith further emphasises the biochemical and biogenetical aspect of the work reported at the Symposium. Certain aspects of catechin chemistry, particularly the factors giving the polymerisation of catechins, are discussed by that great master, K. Freudenberg, and Wilson Baker and W. D. Ollis provide a valuable review of developments in the synthesis of *iso*flavones.

In the second section of the Symposium, T. H. Simpson gives an account of a novel and potentially valuable method for the protection of phenolic hydroxyl groups, in flavone synthesis, by *iso*propylation. The synthesis of the hitherto almost unknown 3-aroylbenzofurans and their isomerisation to *iso*flavones was discussed by W. B. Whalley, whilst H. Schmid has further investigated the complex constituents of *Ammi visnaga* and shown them to be chromano- and coumarono-α-pyrones. Factors governing the Elbs persulphate hydroxylation reaction, used extensively by Seshadri to simulate biological hydroxylation processes, were discussed by R. G. R. Bacon.

An outstanding contribution to the chemistry of leucoanthocyanidins and anthocyanidins and to the theory of their biogenesis is provided by F. E. King's description of melacacidin, the first flavan 3:4-diol to be isolated and characterised.

The papers submitted to the Symposium form a valuable addition to the literature in this field. W. B. W.

AWARDS FOR ESSAYS ON CORROSION SCIENCE

The Education Panel of the Corrosion Group, Society of Chemical Industry, has announced a further competition designed to encourage those who are still in the early stages of their career to take an interest in corrosion science and to express their ideas in writing. With the support of interested industrialists, a prize of the value of 25 guineas will be awarded this year for an essay or paper on any aspect of the corrosion of metals and its prevention.

Essays of about 4,000 words are invited from persons aged not more than 27 years on 31 March, 1957.

The Judges will look for evidence of critical faculty and originality of thought, and for technical and literary excellence generally. Results of original research may be incorporated, but this is not essential; entries may consist, for example,

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of surveys of knowledge in a particular field, discussion of practical problems and suggestions for future developments in research, in the application of knowledge or in the organisation of preventive measures. Where the work or ideas of others are referred to, acknowledgment must be clearly made.

The prize may be withheld if, in the opinion of the judges, no entry is of sufficient merit. Additional prizes may be awarded at the discretion of the judges. A successful candidate may subsequently be invited to deliver his or her contribution as a lecture. Publication will rest with the Society of Chemical Industry, but if the Society does not exercise its right, the entrant will be free to publish his work in any journal.

Entries should be typed (double spaced) on one side of the paper only, with adequate margins. The candidate's name must not appear on the script. The entry must be enclosed in a sealed envelope bearing a pen-name, and a letter bearing the pen-name and including a statement of the full name, address and date of birth of the author must accompany the entry. Illustrations (diagrams and photographs) may be included with the entry in the sealed envelope, but must not provide means of identifying the author.

The closing date for receipt of entries is 31 March, 1957. Entries should be addressed to Corrosion Group Essay Competition, c/o Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

NEW AND RECENT PUBLICATIONS

The New Scientist.—The proliferation of scientific journals is already so considerable—some, indeed, would say excessive—that it would be pardonable to greet yet another with considerable reserve. But this newest recruit need excite no misgivings, for it fills a definite gap and fills it very well. If the standard of this first issue is maintained it deserves to do well.

There are, it is true, already many excellent journals which cater for the scientist who wishes to read outside his own special subject and for the layman sufficiently interested in science to be prepared to take his reading seriously. But we have hitherto lacked a journal which, while of a rather lighter character than these, is not so 'popular' as to be almost without substance, and which appears sufficiently frequently to be able to deal promptly with subjects of topical interest. This lack is met by *The New Scientist.* It promises to be of material assistance in effecting the wide and swift dissemination of scientific knowledge and ideas which is vital to our survival in a highly competitive technical world. Indirectly, too, it is likely to be helpful in the same way, for it can scarcely fail to induce some of the other serious weeklies dealing with current affairs to give more attention to science than they have hitherto done.

Having extended a deservedly warm welcome to a promising new venture it is perhaps not out of place to make a plea here for more items of essentially chemical interest, for in this respect the first issue is a little disappointing. This is perhaps no more than a reflection of the fact, painfully familiar to all who have a serious interest in popular exposition, that of the major branches of science chemistry is much the most difficult to explain to the general reader. The remedy, however, must lie to a considerable extent in the hands of chemists themselves, and the publishers would doubtless welcome material of a chemical nature if it were suitable in other respects.

The annual subscription rate is 60s. T. I. WILLIAMS

Fifth World Power Conference.—The Austrian National Committee of the World Power Conference has announced that the bound Transactions of the Fifth World Power Conference will be published in 20 volumes in the spring of 1957. A total of 276 papers touching on all aspects of modern power economy and power technics was submitted to the Conference in Vienna on 17-23 June, 1956.

This Conference was acclaimed as a landmark in the development of power economy, and it has been said the material brought together there represents the most complete information on power problems yet available. The Transactions will be of value to technical experts, research scientist and economists.

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International Conference on Electron Transport.—A distinguished group of scientists attended the International Conference on Electron Transport in Metals and Solids, at Ottawa, on 10-14 September.

Since the results of the meeting will shed new light on many fundamental questions about the way electrons behave in solid substances, a special issue of the *Canadian Journal of Physics*, to be published in December, will contain the collected contributions to this Conference.

The President of the conference was Professor N. F. Mott, F.R.S., who is also President of the International Union of Pure and Applied Physics, whose Executive Committee met during the Conference.

IUPAC: Publication of Conference Reports.—It has been announced that the *Comptes Rendus* of the 18th Conference of the International Union of Pure and Applied Chemistry held at Zurich are to be put on sale. This will enable chemists in general to study the reports.

The complete *Comptes Rendus* are available at 30s., plus postage. In addition three booklets giving reports of Sections can be obtained, *viz.*

Booklet I. Physical and Inorganic Sections: Symbols and Atomic Weights. 3s. 6d.

Booklet II. Organic Chemistry Section: Organic Nomenclature. 7s. 6d.

Booklet III. Biological Chemistry Section: Nomenclature of Steroids. 3s. 6d.

Orders may be placed through the General Secretary, the Society of Chemical Industry, 14, Belgrave Square, London, S.W.1.

Journal of the Chemical and Physical Society.—The third number of this relatively new Journal has now made its appearance from University College, London. The Journal Committee and its two officers, J. Pannel (Editor) and R. E. Cooper (Sales), both Associates of the Institute, are to be congratulated on the success they have achieved and on the variety of the contributions published so far. The present issue contains articles by a number of other members of the Institute: Professor C. K. Ingold, "Organic Chemistry Begins to Grow Up"; Dr J. I. M. Jones, "Biological Control in the Chemical Industry"; Dr D. R. Llewellyn, "Some Aspects of Fractional Distillation and its Applications in the Concentration of Stable Isotopes." In addition, Dr A. D. Allen writes on "Some Aspects of the Organic Chemistry of Silicon," Sir Graham Sutton on "Meteorology Today," Professor C. W. Allen on "Spectrum Line Intensities for Astronomical Purposes," and Professor E. J. Richards on "The Heat Barrier."

EDUCATIONAL

Carlett Park Chemical and Physical Society.—The newly-formed Chemical and Physical Society of the Carlett Park College of Further Education held its inaugural meeting on 25 October, 150 members being present. The Inaugural Lecture was delivered by Professor T. P. Hilditch, C.B.E., F.R.S., who was introduced by the President of the Society, Mr H. R. Jones.

In wishing the Society and its members all possible success, Professor Hilditch referred to the objects of a College Society and emphasised the pleasures as well as the advantages to be gained by social contacts between the members.

Professor Hilditch chose as the title of his address "Give and Take in Pure and Applied Chemistry," and in it he illustrated the interdependence of 'pure' and 'applied' chemistry by the history of the fat-hydrogenation process.

The development of this process was traced from the original experiments of Sabatier through their early application to the hydrogenation of cheap fatty oils, the fundamental studies on the constitution of the oils and fats and the mechanism of the hydrogenation process. The latter studies led in turn to the processes for reducing the acidic groups of fats and oils to alcohols and the development of the hydrogen sulphates of these alcohols as detergents. Later fundamental work on the isomerisation of diene and triene acids to conjugated forms

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and the use of low-temperature crystallisation led to technical processes for the improved production of stearines and oleines and for segregating the more unsaturated acids present in some fatty oils to give better materials for the paint and varnish industries.

The inaugural meeting closed after a vote of thanks proposed by Mr A. Byrne and seconded by Mr D. J. Wallin (Hon. Secretary) had been carried with acclamation.

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Developments in Technological Education.—In the House of Commons on 25 October Sir Ian Fraser asked the Minister of Education what progress had been made in the extension of facilities for technical education since the publication of the White Paper. Sir David Eccles referred to the Official Report, in which it was stated that apart from the opening of new buildings and extensions, the building programme for 1957–59 had been approved. "Local Education Authorities already know that they can start nearly £40m. worth of the five-year programme of capital investment, totalling £70m." Eight colleges had been provisionally designated as Colleges of Advanced Technology; two of these had been confirmed and others would be confirmed shortly. The National Council for Technological Awards (Curzon Street House, Curzon Street, London, W.1) had published its conditions for giving the Diploma in Technology and was considering a number of applications for approval of courses. The number of sandwich courses had risen from 103 in 1955 to 168 in 1956. Substantial increases in salary for technical college teachers had been approved. The supply and training of teachers for technical colleges was to be reported upon by a committee drawn from the National Advisory Councils for Education for Industry and Commerce and for the Supply and Training of Teachers, under the chairmanship of Dr Willis Jackson, F.R.S. The publication of the White Paper, and subsequent discussion of it in public and private, have made the whole country increasingly aware of the vital importance of technical education and have made a great difference to the climate of opinion in which the education service works.

On 1 November Mr Callaghan asked the Minister of Education to what extent the eight advanced colleges of technology had been able to secure adequate teaching staff to cope with students registered for the new Diploma of Technology. Mr Vosper replied that no courses had yet been approved for the new Diploma and that the colleges in question were securing the staff they required.

East Midlands Regional Advisory Council.—The Report of the Regional Advisory Council for the Organisation of Further Education in the East Midlands for 1955-56 notes that it has now been agreed to issue annually a bulletin of specialist and advanced courses in the Region, as their number is increasing every year and is likely to be further stimulated by the White Paper on Technical Education.

The Regional Academic Board is of the opinion that potential talent available in some areas in Secondary Modern Schools must be taken into account when considering recruits for advanced courses. It also intends to pay more attention to the increased entry of girls into scientific and technical work and to play a part in stimulating parents to take a greater interest in technical education. The Advisory Panels are to be requested to consider how particular studies in their own branches of technology might be liberalised.

Several of the Panels have been very active. The Fuel Panel broke new ground by preparing and publishing a booklet on "The Efficient Operation of a Central Heating Boiler," of which 12,000 copies have been sold in all parts of the country. The Textiles Panel has concentrated on courses, and the Sandwich Course in General Textile Technology at the Derby and District College of Technology is mentioned. Some 17 members of the Advisory Panel for the Chemical Industry are members of the Institute, whose official representatives are Mr S. W. Atherley and Mr R. Betteridge. Mr G. F. Hall, M.B.E., represented the Association of Public Analysts and Mr T. H. Stothard the Association of British Chemical Manufacturers.

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Copies of the Report can be obtained from H. L. Tolley, Secretary, 12 King John's Chambers, Bridlesmith Gate, Nottingham, price 2s.

Scientific and Engineering Manpower.—A joint paper issued recently by the Office of the Lord President of the Council and the Ministry of Labour and National Service ("Scientific and Engineering Manpower in Great Britain," H.M.S.O., 1s. 6d.) enquires into the number and distribution of scientists and engineers now in employment and the likely trend in future demands.

In considering the conclusions reached it should be remembered that in this report 'scientist' includes mathematicians and 'engineer' includes graduates in chemical engineering and metallurgy. Further, these terms include only those with degrees or professional qualifications. It does not include holders of Higher National Certificates.

The report estimates that there are at present some 51,000 qualified scientists in employment in the usual fields and about 5,000 in fields not covered by the enquiry. In addition there are nearly 79,000 engineers. Of the scientists and engineers in Government employment, just over one-half are in the defence departments (including the Ministry of Supply), just over a quarter in the civil departments and one-sixth in the research departments.

By 1959, manufacturing industry has stated, its requirements will be 37 per cent above the present level and Research Associations 24 per cent, and it is calculated that the Nationalised Industries and the U.K. Atomic Energy Authority will require a 22 per cent increase. The percentage increase for the whole of industry is 33 per cent. The corresponding increase in demand for Government, Local Authorities and teaching is estimated at 14 per cent. When categorised, the probable demands work out as a 22-23 per cent increase in chemists, physicists and geologists; a 47 per cent increase in chemical engineers; a 38 per cent increase in metallurgists; but only a 12-13 per cent increase in mathematicians and biologists.

The 'broad conclusion' of the report is that for an annual growth of 4 per cent in total industrial output, the number of qualified scientists and engineers in appropriate employment must be raised from the present 135,000 to 220,000 in 1966 (70 per cent more engineers, 50 per cent more scientists). It is further estimated that the number of people qualifying each year in science and engineering would need to increase from about 10,000 in 1954-55 to about 20,000 in 1970.

The Scientific Manpower Committee says: "This is a statement of a minimum goal which needs to be achieved if the economy is to grow at an acceptable rate. If the universities and technical colleges can achieve more so much the better. We are reluctant to believe that less could be accepted as a target."

CORRESPONDENCE

DR JAMES SANDILANDS JUBILEE FUND

SIR,—Members of the Institute who contributed to the Dr James Sandilands Jubilee Fund may be interested to know that the excellent response has made it possible to set aside a sum of approximately £260 for the endowment of two prizes for Practical Inorganic Chemistry in Dr Sandilands's name, to be awarded annually—one to day-class and one to evening-class students in the Heriot-Watt College.

About 90 contributors attended the reunion dinner held in the Adam Rooms, Edinburgh, on 29 October, at which Dr Sandilands received as a personal gift a shooting-stick, together with a cheque and a volume containing the signatures of all contributors to the Fund.

HUGH H. CAMPBELL,
ROBERT G. M. DAKERS,
Joint Secretaries.

Heriot-Watt College,
Edinburgh.

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SCIENCE AND THE NATION

SIR,—The thought occurs to me that there must be a number of men of my generation who, like myself, were something of pioneers in introducing science into industry in the 1920s. In those days, much resistance had to be overcome, as chemists were often regarded as luxuries, and we learned the hard way how to apply our ideas.

I feel we may have something to contribute in current discussions on the necessity for increased scientific awareness among schoolboys and students, the general public and business men; that we older men can perhaps show that science is not a thing apart to be dismissed from the mind as too remote, but that it is a part of everyday life—and thus create popular interest.

To do this it is essential to make science intelligible to the mass of the people in terms of their everyday life and in simple language that they can clearly understand.

It is surprising how ignorant capable business men are of simple scientific facts and how they regard them as above their heads, when perhaps such simple knowledge might influence important decisions.

Perhaps this is due partly to the classical educational tradition, and this is a challenge I would be prepared to take up.

I am sure it is the general feeling that the Institute, with its responsibilities for the profession, must be the organising body to direct the great pool of knowledge and assistance which is freely available among members.

It is good news therefore that a promising start has been made by the establishment of the Institute Fund for the Development of Education in Chemistry, and we all wish the Fund well in its vital job of 'selling science' to the nation. Unless this is done, and the country as a whole becomes more technically efficient, England's days as a Great Power must be numbered.

19, The Mead, Beckenham. H. J. PALMER

SIR JOHN FOX

SIR,—I write with Dr Nicholls's concurrence to repair an omission in his biographical sketch of the late Sir John Fox (*J.*, 581).

As Dr Nicholls points out, Fox had reached retiring age at the outbreak of the last war, but was retained as Government Chemist until his death.

From 1940 onwards, by arrangement with the Treasury, he was seconded on a part-time basis to the Ministry of Supply in the anomalous, but extremely effective, capacity of an Assistant Director of Scientific (later Chemical) Research. His encyclopaedic knowledge of chemistry and its ramifications, coupled with his friendship with academic and industrial chemists all over the country and his astonishing energy, enabled him to make a vital contribution to the organisation of wartime chemical research.

For five hectic years until his death, Fox dealt with the affairs of the Government Laboratory in the mornings, did a man-size job in the Ministry of Supply in the afternoons (or vice versa) and during three of these found the energy to preside over the activities of the Institute of Chemistry. His regular late-night reading was scientific literature.

Fox certainly died in harness.

72 Epsom Road, Guildford, Surrey. F. ROFFEY

NATIONAL SERVICE AND THE CHEMIST

SIR,—Individuals may have somewhat differing experiences during their period of National Service, but the fact remains that the majority of R.I.C. Graduate Members will spend two years as Other Ranks in the Army. I think that Graduate Members who are enlisted after they have read Mr Johnston's article (*J.*, 535) may receive a very rude awakening. They will find that initiative and original thought are discouraged in the ordinary soldier. In fact the

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attitude of the men who are destined to make a success of Army life is aptly expressed in the two lines:

"Our's not to reason why,
Our's but to do or die."

The technologist is obviously unsuited for such an existence. He will certainly have difficulty in adapting himself to a system in which only repeated threats of disciplinary action avert complete chaos. Such experience in my opinion results in an unbalanced outlook on life.

Having spent a few years in industry I fail to see in what way, apart from mixing with all types of people, National Service can benefit the prospective industrial executive. The qualities required for industrial leadership have little in common with those required for military leadership. For the majority National Service is a waste of time. There are always so many things one is forbidden to do and so little work that requires any mental effort or technical knowledge. The result is boredom, frustration and frequently bitterness. Surely it would not be impossible to introduce a scheme whereby trained chemists could be conscripted for two years to do work of national importance in which their skill is required.

The large-scale deferment of chemists in the 1939–45 war suggests that in the event of large-scale mobilisation few chemists would be available for military service. Thus the military training received under the National Service scheme is really a waste of time and money.

The prospective graduate is often advised to carry out his National Service obligation after leaving school and before embarking upon more advanced studies. I would say this is very bad advice. During two years in the forces the student will forget much of the knowledge acquired at school; furthermore the ex-serviceman frequently has a dislike for mental effort which is not overcome until several months after demobilisation.

J. BUCKETT

11 Meadow Close,
Ruislip, Middx.

RIGHT WORD, WRONG WORD

SIR,—Having read the review of *Right Word, Wrong Word* by Mr A. L. Bacharach in the October issue of the *Journal* (*J.*, 584) I should like to comment upon his penultimate sentence. This begins with the words: "They are on my nearby shelf along with Fowler (*whom* I seldom open) and Gowers (*whom* I frequently do) . . ." The names of the authors of these books in this context imply the books themselves and therefore *whom* instead of *which* can scarcely be justified.

I am tempted to enquire whether Mr Bacharach opens Fowler and Gowers for the purpose of removing their *appendices* or consulting their *appendixes*.

A. J. TURNBULL

108 The Ridgeway,
Enfield, Middx.

SMALL LATIN, AND LESS GREEK

SIR,—Some little while ago I had the temerity to point out to a well-known film critic that she had misquoted Samuel Johnson. For this piece of gratuitous pedantry I received from the lady a characteristically courteous reply, in which she not only admitted that she had been wrong and that I was right, but even thanked me. She added—and surely every scientist must endorse her opinion—that whatever the haste one should always find time to verify one's quotations.

According to Boswell, at any rate, what Johnson had said was "Ignorance, madam, pure ignorance." And that, *mutatis mutandis*, is what I say in answer to a deserved rebuke from Mr H. F. Frost, *Fellow*, who charges me with misquoting the other Jonson in my review (*J.*, 584) of V. H. Collins's *Right Word, Wrong Word*. For "rare Ben" did not write, as I did, along with most other would-be quoters, "little Latin and less Greek," but "small Latin, and less Greek."

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I will not try to duck Mr Frost's yorker by pleading that omission of the quotation marks in my review showed me to be paraphrasing rather than quoting. To make such a plea would simply be to lie, for I certainly thought that I was quoting when, in fact, I was misquoting, through neglect of that film critic's advice. Let this be a lesson to me—and to you, Sir, and the proof-reading members of the Publications Committee, who all passed the misquotation.

While wearing my ill-fitting white sheet, may I also correct another unnoticed error? The plural of *keras* (horn) should have been printed as *kera*, not *kerata*.

As to Mr Turnbull's criticism, I can only express surprise that he appears not to recognise the transferred epithet and similar mildly rhetorical devices. Would he object to "I have a bedside Shakespeare (or Wisden or Debrett), whom I read nightly"? Mr Turnbull must not confuse idiom, of which I was certainly guilty, with idiocy, of which I was not.

May I add that every quotation—or reference to one—in this letter has been checked in the O.D.Q., to whose editors and publishers I am once more, as so often before, deeply grateful, no less than to Mr Frost? And my apologies are due to that same O.D.Q. for failing on at least one occasion to use it properly by being wise before the event, to the readers of this *Journal* for misleading some and paining others (no doubt the majority) and, last but not least, to the late Ben Jonson.

A. L. BACHARACH

26 Willow Road,
London, N.W.3.

BEER FOR THE BOYS

SIR,—Mr L. N. Bawdell in his reply to Mr Meredith Brown makes a rather wide assumption in suggesting that "all scientists understand that 'Beer is Best'." I am not a prohibitionist in the sense used by the latter but I rather regret the extra publicity which has been given to the over-advertised drink trade by the quite un-biased B.D.H. advertisements and the subsequent exchange of letters.

It is, regrettably, regarded by most as socially proper to take alcohol in one form or another, just as it is to exchange cigarettes, but surely many scientists understand that ethyl alcohol (the *chemical* which produces the rather pathetic expression on the face of the apparently senior—but very irresponsible—chemist in the advertisement) is a drug with demoralising, habit-forming properties to certain individuals who are so pre-disposed.

By all means let us have expressions like "Beer for the Boys," or "Beer for the Happy Scientist" if you like, but not "Beer is best," because this is a categorical statement, completely at variance with many observed facts—and so not true and certainly not scientific.

"SCEPTICAL CHEMIST"

39 Lansdowne Road,
Littlehampton.

CHANGES OF NAME AND ADDRESS

(1) The Society for Analytical Chemistry has moved into its new offices at 14 Belgrave Square, London, S.W.1 (Telephone: Belgravia 3258). This is now the address also of the Editorial Offices of *The Analyst* and *Analytical Abstracts*, and the Secretarial Offices of the Analytical Methods Committee.

(2) The registered address of the Association of Public Analysts is now Bank Chambers, 16 Southwark Street, London, S.E.1.

(3) The address of the Bristol College of Technology is now The College of Technology, Ashley Down, Bristol 7 (Telephone: Bristol 4–1241).

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THE REGISTER

NEW FELLOW

(C) BROOKES, Alfred, M.B.E., F.P.I.

ASSOCIATES ELECTED TO THE FELLOWSHIP

(H) SINAR, Ronald, B.PHARM., B.SC. (LOND.), F.P.S.
(OF) VIOL, Frank William, B.SC. (LOND.)

NEW ASSOCIATES

(S) ALMOND, Joseph
(P) HOLDING, Arthur Frederick LeCore, B.SC. (LOND.)
(K) SCOTT, James Sykes McIvor

NEW GRADUATE MEMBERS

(J) ANGUS, Henry John Flockhart
(P) ARNOLD, Peter Edmund
(P) BATEMAN, Ralph John Charles
(E) BENJAMIN, Colin
(O) BIRD, Arthur, B.SC. (LOND.)
(O) BODEN, Harold
(C) BROCKINGTON, John
(J) CAIRNCROSS, Ian Macleod, A.H.-W.C.
(P) CARTER, Terence Leonard
(P) COLLINS, Robert Eric
(P) CONDLIFFE, William Frank, B.SC. (LOND.)
(P) CULBERT, Dennis Peter Alexander
(O) CUSHNIE, Alexander James
(D) DEAR, Robert Ernest Arthur
(O) DUNCAN, Arthur Henry
(P) GRAHAM, John Frederick
(N) GREAVES, Brian, B.SC. (LOND.)
(P) GREEN, Gerald Ernest, B.SC. (LOND.)
(P) GREENFIELD, Bernard Frank
(P) GUSSEFELD, Gunter William
(O) HALEWOOD, Gerard
(O) HAMILTON, John Donald
(Q) HARRISON, Leslie, B.SC. (LOND.)
(C) HATELEY, Roger John, B.SC. (LIV.)
(D) HERNIMAN, David William
(D) HUNT, Robert Charles
(P) JACKSON, Douglas Valentine
(P) JOHNSON, Derek Ivor Oliver
(O) JOHNSON, Eric George
(Y) KIRKHAM, John
(O) KNIGHT, Leonard Cuthbert
(N) KUHNEL, Mervyn Redfern
(D) LLOYD, William John Warren
(O) LYON, John, B.SC. (DUNELM.)
(U) MCLAREN, Duncan Roy Wilson, A.H.-W.C.
(K) MACORKINDALE, James Byers
(U) MAYCOCK, Percy, B.SC. (LOND.)
(E) MILES, Norman John
(C) MORGAN, Peter Ernest
(WW) MORTON, George
(O) OWENS, Dennis Raymond
(P) PAINE, Derek Henry
(D) PALMER, Peter Joseph
(O) PARTON, Cyril
(H) PATRICK, John William, B.SC. (LOND.)
(N) RAWSON, Douglas Hall
(FF) RENWICK, Gordon McArthur, B.SC. (ST. AND.)
(SS) ROBBINS, Derek
(O) ROBERTS, John
(J) SCOTT, Kenneth Alexander
(Y) SHIPP, Horace Frederick
(K) TAUBINGER, Robert Pavel Ludovit Viliam
(O) WALKER, Alan, B.SC. (SHEFF.)
(Q) WILBURN, Peter
(E) WILLIAMS, David Glanville
(C) WILLIAMS, Kenneth Arthur, B.SC. (BIRM.)
(R) WISEMAN, Edward Harry, B.SC. (BIRM.)
(O) WORTHINGTON, William John

DEATHS

Fellows

(D) BARRACLOUGH, William Herbert. Died 20 September, 1956, aged 88. *A.* 1889, *F.* 1892.
(D) BRAZIER, Sidney Albert, O.B.E., M.SC. (BIRM.), F.I.R.I. Died 25 November, 1956, aged 66. *A.* 1917, *F.* 1923.
(N) DENBIGH, George James, M.SC. (LEEDS) Died 4 November, 1956, aged 74. *A.* 1918, *F.* 1924.
(O) MATTHEWS, Robert Karran. Died 2 October, 1956, aged 57. *A.* 1932, *F.* 1935.
(P) RAWLING, Sidney Owen, D.SC. (LOND.) F.R.P.S. Died 2 November, 1956, aged 63. *A.* 1917, *F.* 1925.

Associates

(K) ARMSTRONG, Alasdair William, B.SC. (ABERD.). Died 18 November, 1956, aged 52. *A.* 1941.
(R) MOTT, Owen Eldred, B.SC. (LOND.). Died 16 November, 1956, aged 33. *A.* 1944.
(OB) STEWART, George, B.SC. (GLAS.). Died 14 September, 1956, aged 65. *A.* 1927.
(K) THOMSON, Thomas, B.SC., PH.D. (GLAS.). Died 21 November, 1956, aged 47. *A.* 1930.

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LOCAL SECTIONS DIARY

Sections are glad to welcome members of other Sections to their meetings and social functions, except when numbers are restricted, as for works visits. Those wishing to attend meetings outside their own area are advised to write to the Hon. Secretary of the Section concerned, as the Institute cannot accept responsibility for any alterations or cancellations. All times are p.m. except where otherwise stated.

(A) **Aberdeen.** 27 and 28 Dec. 3. Christmas Lectures. Colour. H. H. Summer. Chemistry Dept., The University. Joint, C.S. and S.C.I.
— 18 Jan. 7.30. The Character of Paint; Newer Developments. A. T. Rudram. Physiology Lecture Room, Marischal College. Joint, C.S. and S.C.I.

(B) **Belfast.** 2 Jan. Afternoon Lecture and Demonstration for Schools. Modern Petrol. W. H. Adams. Agriculture Lecture Theatre, Elmwood Avenue

(O) **Birkenhead.** 24 Jan. 7. Molecular Spectra and Molecular Structure. Dr M. Davies. Technical College, Borough Road

(C) **Birmingham.** 22 Jan. 6.30. Some Aspects of the Structural Chemistry of Nucleic Acids and Proteins. Prof. H. D. Springall. College of Technology, Gosta Green

(R) **Bournemouth.** 17 Jan. 7.30. Fluorescence Analysis in Ultra-violet Light. J. A. Radley. Municipal College

(E) **Cardiff.** 25 Jan. 7. Hormones. Prof. S. W. Landgrebe. University College, Cathays Park. Joint, S.C.I.

(FF) **Dundee.** 21 Dec. 7. A Chemist Looks into the Beauty Pot. Dr I. A. Smith. Chemistry Lecture Theatre, Queen's College
— 25 Jan. 7. Some Aspects of the Geochemistry of Uranium. Prof. C. F. Davidson. Chemistry Lecture Theatre, Queen's College

(J) **Edinburgh.** 26 and 27 Dec. 7.30. Christmas Lectures to Senior Schoolchildren. Living, Chemistry and Manufacture. Dr Magnus Pyke. North British Hotel
— 10 Jan. 7.30. Chocolate Manufacture with Special Reference to Cacao Constituents. H. B. Brown. North British Hotel. Joint, C.S. and S.C.I.
— 17 Jan. 7.30. Sections' Dinner. Royal British Hotel. Joint, C.S. and S.C.I.

(P) **Enfield.** 21 Jan. 7. The Use of Photography in Scientific and Engineering Investigations. Dr R. H. Herz. Technical College, Queensway, Ponders End

(P) **Gravesend.** 8 Jan. 7. Film: Corrosion. P. A. Raine. Technical College, Mayfield Hall Annexe, Pelham Road. Joint, Gravesend and Dist. Eng. Soc.

(L) **Huddersfield.** 15 Jan. 7.30. The Application of Sequestering Agents. Dr R. L. Smith. 32, John William Street

(M) **Hull.** 18 Jan. 7.30. The Uses of Chemical Tests in Medicine. J. Parkes. Organic Lecture Theatre, The University

(SS) **Lancaster.** 24 Jan. 7.30. A Chemistry Based on Fluorine. Dr R. N. Haszeldine. Storey Institute

(N) **Leeds.** 14 Jan. 6.30. Problems of Air Pollution. G. Nonhebel. Chemistry Lecture Theatre The University

(H) **Leicester.** 10 Jan. 7.30. Radiation Hazards of the Atomic Age. Prof. F. W. Spiers. Room 104, College of Technology. Joint, L. Coll. Art Tech.

(P) **London.** 16 Jan. 6. The Chemistry of the Newer Elements. Prof. H. J. Emeléus, F.R.S. King's College, Strand, W.C.2. Joint, London Section, S.C.I.

(Q) **Manchester.** 3 Jan. 2 p.m. to 8 p.m.; 4 Jan. 10 a.m. to 8 p.m. Exhibition of Laboratory Apparatus and Chemical Techniques. College of Science and Technology
— 4 Jan. 6.15. Annual General Meeting. College of Science and Technology
— 16 Jan. 6.30. Studies of Knock and Anti-Knock by Kinetic Spectroscopy. Prof. R. G. W. Norrish, F.R.S. Chemistry Lecture Theatre, The University. Joint, C.S. and S.C.I.

(X) **Middlesbrough.** 24 Jan. 8. Oxidation of Hydrocarbons. Prof. C. E. H. Bawn. Constantine Technical College

(G) **Norwich.** 24 Jan. 7.30. Food Legislation since 1939. C. A. Adams. City College

(W) **Plymouth.** 18 Jan. 5.30. Silicosis. Prof. E. J. King. Technical College. Joint, S.A.C.

(R) **Portsmouth.** 14 Jan. 7. The Training of a Chemist. Dr A. M. Ward. College of Technology. Joint, Portsmouth and Dist. Chem. Soc.

(R) **Salisbury.** 8 Jan. 7.45. The Uses and Abuses of Science in Archaeology. Prof. S. Piggott. Cathedral Hotel

(EE) **Seascale.** 18 Jan. 7.30. Mechanisms of Chemical Change. K. D. Wadsworth. Windscale Club. Joint, S.C.I.

(WW) **Stirling.** 16 Jan. 7.30. Short Papers by Members. Golden Lion Hotel. Joint, S.C.I.

(Q) **Stockport.** 31 Jan. 6.30. Recent Advances in the Chemistry of Amines. Dr H. B. Henbest. College for Further Education

(V) **Swansea.** 25 Jan. 6.30. Inorganic Semi-Micro Analysis. H. Holness. University College. Joint, College Chem. Soc.

(P) **Walthamstow.** 30 Jan. 7. Some Aspects of Inorganic Peroxy Compounds. R. Lait. S.W. Essex Technical College, Forest Road, E.17. Joint, College Chem. Soc.