for high-energy X-ray fluoroscopy. Work in thin-film technology has been considerably developed and has concentrated on the electrical application of thin films.

The British Steel Castings Research Association is developing special methods of applying materials and has shown that chromite sand is a valuable substitute for zircon sand. Tests have shown that, using this method, austenitic manganese steels can be produced from scrap more economically than by previous methods. Trials are at present proceeding to assess the efficiency of deoxidizers which could lead to the production of superior steels at a lower economic cost.

Research in plant engineering has included the wet reclamation of clay-bonded sand, and investigations of the efficiency and rate of cleaning of steel-castings have shown how shot and other abrasives can be used more efficiently and can provide a method for removing very hard and tenacious cores. In welding technology, the use of a gas shield around a welding arc has proved of great value during the past few years in solving such problems as the welding of thin aluminium alloy sheets, the positional welding of steel and the welding of a whole range of alloys in which metal transfer in the ordinary gas-shielded welding is difficult and erratic. The British Welding Research Association has also overcome difficulties due to resistance in spot-welding by developing a monitoring device which gives a reliable indication of the occurrence of defective welds during the welding operation. Progress already achieved in welding high-tensile steels made it possible for welding to be used in constructing the Forth Bridge, and this is estimated to have cut construction costs by £1 million. A completely new method has been developed for the hydrogen analysis of metals, and methods and equipment developed by the Association to test very large steel plates are now used in every industrial country.

The Welwyn Hall Research Association was formed on October 1, 1964, by the amalgamation of the Whiting and Industrial Powders Research Council and the Chalk, Lime and Industries Research Association. During the past 5 years the Council has advanced over a broad front, rather than in particular fields. The latter Research Association, however, has investigated particularly the problems of the heat balance of shaft lime-kilns and their operation, and this has led to a better understanding of the factors affecting fuel efficiency. An investigation of the factors affecting the quality of calcium silicate bricks has also been undertaken, which has led to the manufacture of stronger bricks with greater dimensional stability.

SPACE AGE SCIENCE AND TECHNOLOGY

APART from what the Earl of Bessborough said in his opening speech, the debate on space age science and technology in the House of Lords on November 3 is of interest mainly for what Lord Shackleton said about Britain's effort in this field and for what Lord Bowden and Lord Snow, who replied to the debate, said about the organization of our research effort and the choice of priorities. The Earl of Bessborough asked some searching questions about the extent of our effort in space research, with which he was dissatisfied. He did not suggest that this effort was necessarily more important than that concerned with other scientific and technological needs, particularly in the less developed countries. The research effort was considerable, but he was concerned that the overall proportion of our research expenditure in the main fields should be right. Lord Shackleton referred to the brilliant report of the Bondi Committee, but said that it could not be published for security reasons. The original estimate of the cost of the European Launcher Development Organization was £70 million, of which our share was 38·8 per cent. When the studies for further programmes were available early next year we should have to consider the estimate very carefully in relation to the technological advantages to be derived from the present and possible future programmes. Concerning satellite communications, he said that the United Kingdom, France and several European countries established in 1963 the European Conference on Satellite Communications and, in the following year, negotiations with the United States, Canada, Australia and Japan led to the drafting of two interim agreements. These covered the establishment of a global satellite system under the Interim Committee on Satellite Communication on which the United States was represented by its Communications Satellite Corporation.

At present there was no alternative to the use of United States launchers and satellites. The *Early Bird* satellite, which is now in regular service and carries part of our transatlantic telephone service, was commissioned before the agreements were signed. It is expected that we will have a global service and that this will render an economic return in due course, but it will take some time for the system to reach a level of development which will be economic. Satellite *Early Bird* was primarily an experiment to determine, first, whether a satellite of this type would provide an acceptable telephone service and, secondly, to gain operating experience. The specification for future satellites which has now been drafted aims at an average life of five years, and it is hoped that, in the future, ten years will be achieved. Although the United Kingdom and the European Launcher Development Organization have the range and supporting facilities of Woomera, there are great advantages in equatorial orbits, and some consideration is being given to the possibility of an alternative launching site near the Equator. Work in Government establishments and in industry on the basic satellite-technology programme has covered design and technological problems relating to satellites, including studies for astronomical satellites and communication satellites and research and development on solar cells, the effect of space environment on electronic components, altitudes sensing, and control systems. Defence Research Establishments had been working on methods of space communication without using man-made satellites. Notable advances in weather forecasting had already been made through the use of space techniques. In the current year the level of expenditure in this field looked like being about £20 million.

In a maiden speech, Lord Ironside referred to the European Space Research Organization Convention, which came into force on March 23, 1964, in which ten countries were now participating, Austria and Norway having dropped out. Much expenditure was at present capital, but the emphasis was slowly shifting to project work. Contributions to the European Space Research Organization, at present something like £7 million, were expected to approach £20 million a year in two or three years' time. Lord Ironside said he thought the return to this country would come first through the return of technologists, after service abroad, and through the placing of contracts in this country by the Organization, which would strengthen United Kingdom industry in space technology and stimulate advances in related technologies, such as telecommunications, vacuum techniques and cryogenics. Lord Bowden's speech was essentially concerned with the organization of civil research and the choice of priorities, and he claimed that the new Council on Science Policy constituted a notable advance. He asked whether the Government proposed to publish Prof.

Flower's survey of the requirements of the universities, and he again expressed his concern that our choice of priorities might be wrong. Lord Shorfield thought manned space research was an example of the fields in which we could not compete. He urged that in the choice of priorities we should build on success and give priority in resources to advanced fields in which we were either still in the lead or among the leaders, instancing nuclear research and technology, fusion research, radiochemistry, radio astronomy and important areas of the biological sciences, as well as some sectors of aviation. He also emphasized the importance of international co-operation, either with single countries as with France in the *Concord* project, or with groups of countries as in the organizations already instanced. He suggested that some countries might tend to support their national programme rather than their share in an international programme to which they were also committed and for this reason he preferred a national effort. He thought our organization of research was soundly based, but regretted that the Industrial Research and Development Authority recommended by the Trend Committee had not been adopted; he believed that the establishment of a Ministry of Technology was a mistake.

Lord Todd also offered a warning against excessive commitment to space research and thought that the advantages coming from technological fall-out were exaggerated. Britain should either support technology with a definite economic aim or support primary scientific research rather than projects in which advantages were reaped from technological fall-out. She must beware of putting too much manpower into scientific research and too little of it into pursuit of technological ends; it was imperative that some hard choices be made which would lead to Britain opting out of some fields of science. He thought we would undoubtedly have to double our present expenditure on scientific research during the next five years, that is to say, there should be a growth rate of about 15 per cent per annum during that period; any cut in this would seriously endanger Britain's position as a leading nation.

EARNINGS OF CHEMISTS

AN article in *Chemistry in Britain* for October 1965 commenting on the remuneration survey, 1965, conducted by the Royal Institute of Chemistry, gives some interesting comparisons of the earnings of chemists with those of other professional people and scientists. Figures for 10 professions in 1964 are given by J. Graham in a series of articles for *The Scotsman*. The average median earnings of chemists in Great Britain between the ages of 30 and 65 are shown by the survey as £2,650 in 1965 compared with £1,600 in 1956. These figures compare with figures for university teachers in 1964 and 1955 of £2,350 and £1,500, respectively. For engineers the corresponding figures are given as £2,200 and £1,210; for graduates in industry £2,575 and £1,570; for doctors (consultants) £4,000 and £3,130, and for general practitioners, £2,765 and £2,160. Figures obtained in a survey by the Institute of Physics in 1964 showed that salaries of its Fellows and Associates had risen by just over 72 per cent in the nine years from 1956, compared with a corresponding rise for chemists over the same period of 66·3 per cent. A typical Fellow of the Institute of Physics can expect to reach a peak of £3,400–£3,500 a year, compared with £3,100–£3,200 for a Fellow of the Royal Institute of Chemistry. Looking at the earnings of chemists in various occupations, private industry no longer leads the field; its highest median salary of £3,100 in the 56–60 age group coming third, behind universities and colleges of advanced technology (£3,460) and £3,150 in the Atomic Energy Authority. Starting salaries in the Scientific Civil Service appear to be outstandingly high, presumably because of more recruitment direct into the Senior Scientific Officer grade, and the subsequent prospects also seem to be better than in most other categories of employment. This closing or narrowing of the gaps between median incomes in industry and those in other occupational categories is particularly interesting in view of current discussions on the possible shortage of scientists. It should be remembered, however, that chemists are not a particularly unified group and are engaged in a very wide range of diverse activities, which sometimes have only a tenuous connexion with their qualifications.

A further article in the November 1965 issue of *Chemistry in Britain* comments that chemistry appears to be about middle of the professions surveyed and that it would appear that the median income levels in all the professions are tending to move closer together: a relatively small change of pace in relation to the general forward movement of incomes could drastically alter the position. Chemists still do considerably better financially in some fields of employment than in others, but such differences also seem to be diminishing. The very low proportion of chemists (0·5 per cent) reporting they were unemployed does not suggest a surplus, and of the 55 out of 10,459 without employment, only 29 had been out of work for more than 3 months, 13 of whom were under 40. While the earnings of older chemists have not increased sufficiently to preserve the differential between them and their younger colleagues, the survey encourages the belief that most chemists whose employers regard them as 'too old at forty' have a good chance of finding one who does not. The survey also shows that any movement of chemists away from industry has been comparatively small, although most of the decline, from 59·6 per cent in 1956 to 55·5 per cent in 1964, occurred in 1962–65.

'O'-LEVEL EXAMINATIONS

FOUR years ago R. W. Crossland and R. Amos presented an analysis of 'O'-level papers of the General Certificate of Education (G.C.E.) in biology of four Boards over the period 1948–59. The analysis was an attempt to quantify the emphasis placed on four main outcomes of biology teaching in the contents of the question papers.

These outcomes are: (1) the acquisition of facts, (2) the interpretation of facts and the drawing of conclusions from experiments, (3) the application of scientific principles to new situations, (4) the designing and planning of experiments.

Late in 1962 a similar analysis of the corresponding papers was made for the period 1960–62 and more recently the analysis was brought up to date by including the papers for 1963 and 1964*. The results of the three analyses are here shown separately, and, for comparison, the corresponding figures for the other science subjects are also shown (Table 1).

The analyses show the relative proportions of acquisition of facts and scientific method for the various sciences at 'O' level. Biology papers devote about 90 per cent of questions to facts. There are those who hold that one needs to know a good many biological facts before one can do much reasoning. The authors suggest that the Nuffield Foundation Teaching Project and similar pro-

* *Biol. Hum. Affairs*, **36**, No. 3 (1965).