board? Certainly, the electricity industry itself would probably welcome a chance to finance some of its undertakings from sources other than the British taxpayer—at the very least this would provide a degree of flexibility which is at present lacking. By the same test, the electricity industry should no longer be required to negotiate with the Government before deciding to build a power station of one kind or another.

Smelting at Home

THE British Government wants to save imports by establishing an aluminium smelting industry in Britain. So much is clear. But the idea is now so complicated by wrangling that it seems unlikely to be carried through without ill-will. Internationally, the running has been made by Mr Kare Willoch, the Norwegian Minister of Commerce, who said that the move to establish aluminium smelting in Britain was both illegal and immoral and defied both the EFTA convention and the spirit of free trade. In Britain, the objections are likely to be less easy to brush aside.

The trouble is that Alcan, one of the aluminium companies which wants to build in Britain, has allowed itself to get involved in a long-standing row between the electricity generating boards and the National Coal Board. The coal board, which claims that it is still possible to generate electricity as cheaply by burning coal as uranium, has persuaded Alcan to base its tender on a coal-fired generating station. Although it would clearly be more attractive to Alcan to have the whole smelter complex under its own control (rather than sharing the output of a large nuclear station, which was the original intention), it has been generally assumed that the most compelling argument has been a promise by the coal board to supply coal at knock-down prices.

Both the coal board and Alcan have refused to reveal the price that has been agreed for the coal. It is, however, quite possible to calculate this. Alcan has agreed to take 1 million tons of coal a year from the north-east coal-field, where the cost of coal in 1967 was an average of £5·32 a ton, according to the annual report of the coal board. At this price, Alcan's annual bill would be £5·3 million, even if transport costs were ignored. But Mr John Elton, managing director of Alcan in Britain, has said that power costs amount to no more than 15 per cent of production costs. Aluminium ingots sell at about £228 per ton and, to make the investment worthwhile, Mr Elton will have to produce ingots at about £200 per ton. For a 120,000 ton a year plant, this means annual production worth £24 million. Fifteen per cent of £24 million is £3·6 million, far less even than the cost of fuel if Mr Elton were buying at the going rate. It is clear that he can be paying no more than £2·8 to £3 million a year for coal, equivalent to 3·1*d*. per therm at the smelter. This is very markedly less than the 5*d*. per therm paid by the generating boards, or the 4·6*d*. per therm paid by the National Steel Corporation, both of which are much larger customers.

Even if the deal is approved, Invergordon seems an odd place to choose for the smelter, particularly as it will involve the transport of coal by sea from the north-east of England. Invergordon, it can be argued, is a development area and is thus a candidate for development grants, but so is the north-east. In principle it would be most sensible of all to build the smelters where the ore, bauxite, is mined—in Jamaica, among other places. At present bauxite is converted to alumina in plants in Jamaica and is then carried by sea to the smelters elsewhere in the world.

Slower Growth for Universities

THE publication last week by the University Grants Committee of the grants to individual universities enables a preliminary assessment to be made of the way in which universities are likely to develop over the next five years. Fig. 1 shows the total support provided by the University Grants Committee to the universities in the years between 1957 and 1972. Fig. 2, which takes the University of Birmingham as a particular example, shows the same pattern. What the curves do is to confirm an impression that the years of really rapid growth lie between 1963 and 1968, and are now coming to an end. Beyond 1968 there is evidence of a slackening of support, and it looks as if the growth will return to much the same rate as prevailed before 1963. On this rather pessimistic argument, the stimulation of support for universities which was achieved by the publication of the Robbins Report was little more than a temporary phenomenon.

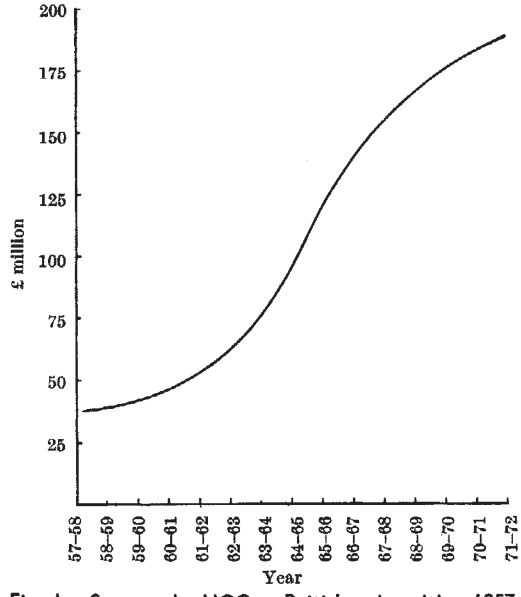

Fig. 1. Support by UGC to British universities, 1957–72.

What is potentially more alarming—to scientists, at least—is that of the more modest increases which are promised to the universities in the next five years, the greater part will be devoted to subjects other than science and technology. In this, as in other things, the UGC has been swept along by the tide. Although Sir John Wolfenden is no Canute, he and his committee do seem to have made some efforts to resist—they provided for a small expansion in science and technology, although the evidence is that the total numbers of students coming forward will actually decline for the next few years. The UGC is clearly terrified that if the swing away from science should reverse itself, and the attractions of social science become less compelling to schoolchildren, it is going to be left high and dry. This is why it has provided

for an increase in science places, although the evidence is that some of them will be left empty, or filled by students less able than their contemporaries in other departments.

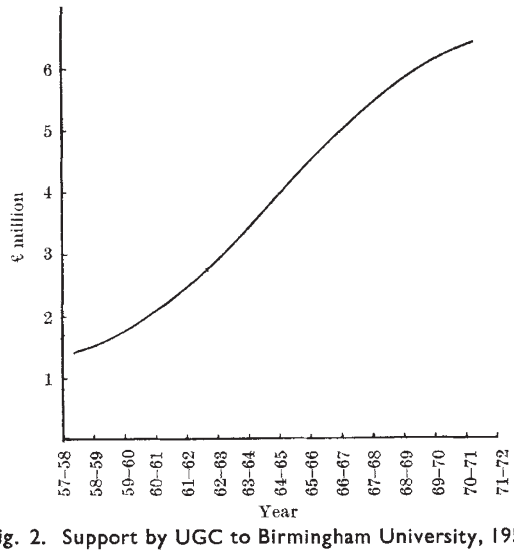

Fig. 2. Support by UGC to Birmingham University, 1957–72.

For the first time, the UGC report includes an interesting survey of the costs of producing graduates in a variety of disciplines. The figures, reproduced below, show how much it costs to produce a graduate in each of the disciplines listed, but do not include the costs of administration, libraries and maintenance of buildings. These costs add up to an additional £260 per student.

ACADEMIC YEAR, 1966–67

	Average Unit Cost	*Average Staff/ Student Ratio*
	£	1:
Arts	276	9·8
Social Studies	255	11·3
Education	261	12·5
Biological Sciences ..	518	8·7
Physical Sciences ..	376	11·3
Technology	425	11·3
Medicine		
(*a*) pre-clinical ..	647	8·2
(*b*) clinical (excluding postgraduate institutes)	790	5·9
Dentistry	778	5·6
Veterinary Science ..	1,136	4·6
Agriculture	497	7·8

Sonic Booms and Superbooms

A PROGRESS report on research into sonic booms has been carried out by a sub-committee of the Committee of the US National Academy of Sciences on SST–Sonic Boom (*Generation and Propagation of Sonic Boom*, National Academy of Sciences. Obtainable in Britain from Universal Subscription Service, Ltd., 4 Footscray Road, London, SE9. 25*s*.). The sub-committee, which was chaired by Dr R. L. Bisplinghoff, professor of aeronautics at MIT, held out no hope for an immediate or dramatic improvement in noise generation.

Progress in supersonic aerodynamics has been such that sonic boom overpressures on the ground can now be accurately predicted to within margins of 10 per cent. But this is only for aircraft flying at constant speed, height and direction and over a quiescent atmosphere. Atmospheric inhomogeneities, such as those caused by temperature variations, wind shears and turbulence, exert a complex effect on the propagation of shock waves which at present is poorly understood. Topographic features and seasonal variations in atmospheric turbulence also exert profound influences on the sonic boom waves that reach the ground, and here again further research is needed.

The phenomenon of "superboom" occurs when shock waves from more than one point of the flight path reach the observer at the same time. This can happen when a supersonic aircraft changes speed or direction, with the result that propagated shock waves are momentarily focused at a single point. Current theory can predict the location of a superboom on the ground but not the size of the pressure wave. The sub-committee is dissatisfied with current investigation into superboom effects, and it considers that more flight and laboratory tests are necessary.

Studies of aircraft design aimed at minimizing sonic boom effects are of prime importance, but the designs so far tested have been relatively conventional. The sub-committee urges that less conventional configuration studies be undertaken in the future. The better radiation characteristics of such fuels as liquid methane or hydrogen hold the possibility of increased propulsion efficiency and possible reduction in sonic boom levels; this is another topic that would merit further attention.

At ground level, little is known about the exact features of the sonic boom which make it undesirable both to animals and to the stability of buildings. The record of the pressure wave as a sonic boom hits the ground, known as its signature, varies both with the type of aircraft and the prevailing conditions. Further research needs to be devoted to determining which parameters of the signature are responsible for damage to human sensibilities on the one hand and to buildings on the other.

It is clear that a large number of problems remain to be solved before the generation and behaviour of sonic booms are thoroughly understood. As far as the Concorde is concerned, the Royal Aircraft Establishment at Farnborough is confident that knowledge of the phenomenon, if not complete, is at least sufficient to allow Concorde flights to proceed. Unforeseen turbulence or topographic effects may perhaps cause prolongation or reverberation of the boom, but they are unlikely to affect the initial sound which is the main cause of annoyance. Unlike military aircraft, which can cause superbooms by abrupt turns or accelerations, the Concorde is expected to produce a superboom only at the period after take-off when its speed becomes supersonic. It is hoped that with suitable planning this superboom can be dumped in the sea.

Industrial Superconductivity

INTERNATIONAL Research and Development Ltd., a sponsored research organization based in Newcastle upon Tyne, announced this week that it has successfully designed and built an electric motor based on superconducting coils. This has been a dream of engineers since superconductivity—the phenomenon in which metals cooled to very low temperatures lose all