board that ordered the reactor in the first place, commissioned three separate designs and agreed to build these before a full prototype was constructed. (The Windscale AGR, well though it has run, is a far simpler machine than the commercial stations, built more for fuel testing than as a proper prototype.) The stations were all approved without detailed design work being undertaken.

It is a similar mess that everyone is trying to avoid this time. The choice is not an easy one. As Sir John Hill, Chairman of the Atomic Energy Authority, said at the Royal Society symposium on energy last week "all reactor systems have some problems". He also pointed out that "every time there is a major change of design there will be difficulties". It is possible that light water reactors will prove the final choice. But the CEBG should admit that the case is not as clear cut as it claims.

AUTOMOBILE POLLUTION

GM Breaks Ranks

by our Washington Correspondent
MOTOR manufacturers have recently failed in a last ditch attempt to keep exhaust catalysts off cars sold next year. For months, executives from the car industry have been badgering Congressmen and Senators, trying to win yet another delay in implementing the stringent exhaust emission controls specified by the Clean Air Act, and the matter finally came to a head early this month when the Senate Public Works Committee held a couple of days of hearings on automobile pollution. Spokesmen for the industry warmed over a number of old arguments, seized upon all kinds of real or imaginary fears, and invoked threats of economic and social disaster if the Clean Air Act is not soon modified. But the chief outcome seems to be a huge split in their own ranks.

They were arguing, essentially, for emission controls to be frozen at their present levels for the next two years, and for some rather more stringent controls to be imposed in 1977. Such a delay would put off the need to fit exhaust catalysts, since the present regulations can be met with engine modifications, and the clear intention is to use the breathing space to work to put off that fateful day entirely.

That, at least, is the position taken by representatives of Ford and Chrysler, who were unstinting in their criticisms of the catalyst. But witnesses from the other member of the big three, General Motors, broke ranks and came out with some extraordinary statements in support of the device. But they, too, want the controls relaxed, although only by a small amount.

In any case, Russell Train, Admini-

strator of the Environmental Protection Agency, said that he is not prepared to recommend relaxing or delaying the standards, and the committee shows no sign of taking the initiative itself. Thus, as John J. Riccardo, president of Chrysler put it, since "action must be taken now, or it will be too late", exhaust catalysts will be fitted to cars sold next year.

It was a last ditch attempt by Ford and Chrysler because the Environmental Protection Agency has already given them the maximum amount of time available to meet the standards, and the only possible way to delay things further would be for Congress to modify the Clean Air Act. The act requires that 1975 model cars emit 90% less carbon monoxide and oxides of nitrogen than 1970 models, and that 1976 models emit 90% less oxides of nitrogen than 1971 models. Earlier this year, however, the motor manufacturers persuaded the Environmental Protection Agency to give them an extra year to meet the standards. But part of the EPA's bargain included a provision which requires that all 1975 model cars sold in California must meet strict emission controls—and that will need the use of exhaust catalysts on those cars. The rationale was to force catalysts to be introduced in California next year—1975 model cars will be unveiled in the Autumn of 1974—and nationwide a year later.

Ford and Chrysler executives argued, as they have done for the past two years, that the catalyst is inherently bad technology, and that they would like to use better devices, such as the stratified charge engine, if only they had the time to do it. But, if they are forced to clean up car emissions immediately, they have no alternative to sinking their money into exhaust catalysts at the expense of developing the other technologies.

Six months ago, that was also the complaint put out by General Motors, but at the hearings earlier this month, Edward N. Cole, the company's president, said bluntly that there is no need to modify the interim regulations set for California in 1975, and that the conventional engine equipped with catalytic converters will be the best method of cleaning up automobile pollution. Cole also said that GM cars will be able to meet the 1975 interim standards, and that catalysts will be fitted not only to cars sold in California, but to others as well.

The effect of the split in Detroit's previously united front had the effect of undermining many of the arguments put up for delaying the standards, and environmentalist witnesses at the hearings had little difficulty in playing off one statement from the car manufacturers against another. But it is

perhaps worth noting, in any case, that only a few months ago, when spokesmen for all three manufacturers were arguing for a year's delay in the 1975 standards, that they all painted pictures of economic disruption and wholesale closures if they were forced to introduce catalysts on all their cars next year. Now, however, not only is General Motors planning to introduce catalysts nationwide next year, but Ford is also planning to fit them to all their California cars and 65% of their others. Environmentalists have been quick to ask what happened to the dire forecasts.

As for the latest round in the battle, the arguments for delaying the standards have revolved around three chief questions—are the standards stricter than necessary simply to protect public health? Will the catalysts lead to another serious health problem, namely, the production of sulphuric acid from sulphur in petrol? And, finally, will they contribute to the energy crisis by decreasing engine efficiency? In each case, Ford and Chrysler argued that it would be sensible to delay implementing the standards until those questions have been answered. Clearly, if catalysts are installed next year and it subsequently turns out that they are not needed, several hundred million dollars will have been wasted.

The question of the standards being stricter than necessary is one on which the manufacturers are almost united, and they have also received direct and indirect support from the National Academy of Sciences for their arguments. In September, for example, Dr Arthur Stern, chairman of an NAS committee which has been looking into auto pollution, said that he believes the standards are three times stricter than necessary. That statement has, of course, been seized by the manufacturers and banded about in committee rooms and Congressmen's offices ever since, but they are looking to the academy to provide even more support for their case next year. The academy has been given a contract by the Senate Public Works Committee to conduct a massive study of the health effects of pollutants, and the car manufacturers are convinced that when it reports next year, the academy will vindicate their own findings that the standards are much too strict.

In any case, the manufacturers have been arguing with some conviction that the 1975 interim standards should be delayed until the academy has produced its report, since, by next summer, catalysts will already be clamped to car exhausts and it will be too late to turn back if the study finds that they are not in fact needed. But the EPA, in the person of Mr Train, testified that relaxation of automobile controls next year would not only take the steam out of the

motor manufacturers efforts to clean up their products, but it would also cause many state governments grave problems in meeting other standards specified by the clean air act. He thus refused to entertain the idea of yet another delay.

As for the question of sulphuric acid emissions, that has already caused a split within the Environmental Protection Agency and raised some genuine fears that the catalyst may cause almost as many problems as it solves. The problem is the catalytic converters oxidise not only carbon monoxide and hydrocarbons to carbon dioxide and water, but they also oxidise some of the sulphur in gasoline to sulphur trioxide, and that could result in dangerous levels of sulphuric acid and sulphates in city air.

The problem first came to light earlier this year, and it prompted the EPA's director of research and development to suggest in an internal memorandum that the introduction of catalysts should be delayed until the problem has been given further study. According to the EPA's latest estimates, cars equipped with catalysts will spew between 3 and 5 times more sulphate into the atmosphere than cars not equipped with converters. Mr Train also stated at the hearings that EPA scientists have concluded that unless a mechanism is developed to control sulphate emissions, "more than one model year of cars equipped with catalysts could result in ambient levels of sulphates reaching levels at which recent studies suggest there will be adverse health effects". The EPA will soon be releasing a technical report on the matter, but in any case Train emphasises that if a problem does arise, there will be ample time to find a solution before there is a public health risk. Moreover, Mr Cole testified that "our (GM's) tests and atmospheric modelling show that while there may be some possibility, there is little probability that roadside atmospheric levels of sulphates from catalyst equipped vehicles by themselves will reach any threshold health levels".

But it is on the question of petrol consumption that General Motors testimony was most seriously out of line with that of the other two motor manufacturers. Until recently, all three car makers have been arguing that the exhaust catalyst will greatly increase fuel consumption, a fact that will not do much to help solve the energy crisis. But, much to the dismay of Ford and Chrysler, Mr Cole told the Senate committee that General Motors' cars equipped with catalysts to meet the 1975 emission standards will consume on average 13% less fuel than models being sold this year. To be sure, part of the reason for the dramatic drop is explained by the fact that GM, along with other manufacturers, will be pro-

ducing smaller cars, but the statement has clearly cut the ground from under Ford and Chrysler's attempts to ride the energy crisis bandwagon to put public opinion on their side in the battle against the catalyst.

Thus it seems inevitable that catalysts will be fitted to some 60% of all cars sold in the United States next year. But the debate will carry on for years to come.

ROYAL SOCIETY

Future Energy Sources

ENERGY in the 1980s, last week's symposium at the Royal Society, painted several different pictures of future trends. Mr D. Clark of the Central Electricity Generating Board, pointing out that his board is the largest consumer of fuel in Europe, stated that coal will be the board's staple fuel until the 1980s, when oil will become increasingly more important. The future after that will lie largely with nuclear power.

Up to the 1980s, Mr Clark said, the board can use all the coal that the National Coal Board can provide providing the price is right. But nuclear power will quickly become economical for lower load factors than at present. With forecasts based on a 5% growth rate, the year 2000 would see 24% of Britain's energy needs supplied by nuclear power. Towards the end of the 1980s, surplus nuclear generating capacity should be available on enough nights of the year to make energy storage a practicality.

But while coal still has a large part to play, Mr Clark was clearly not entirely happy at the prospect. "It is a fact", he said, "that over the last fifteen years electricity production has been hit a lot harder by stoppages in coal supplies than in oil supplies."

He also suggested that the volume of ordering of new coal-fired plant will be too small for technical innovations of any dramatic kind in coal plant.

Mr Leslie Grainger of the National Coal Board disagreed. By his calculations, the price of coal has virtually to double before nuclear power becomes competitive for low load generation. Advances in coal utilisation such as fluidised combustion, liquefaction and gasification were all put forward.

"The time has come", Mr Grainger said, "when we should increase the scale of this operation". A demonstration fluidised combustion plant should be built and a fluidised liquefaction plant producing 10 tons a day should be constructed (a half ton a day plant is already running). Coal is going to be very important on a world scale for many decades, Mr Grainger added, and will increasingly be used for conversion to other forms of energy.

Mr E. B. Walker of Gulf Oil Cor-

poration was also optimistic about energy conversion. His interests lay in converting tar sands, oil shales and coal. By 1985, he predicted, 3.75 million barrels of synthetic oil a day will be being produced in the USA. "This will reduce the United States demands on world supplies," he added, "and will therefore greatly strengthen the free world", although it is highly unlikely that any of the synthetics will be exported. Oil extracted with hot water from tar sands is already being produced at the rate of 50,000 barrels a day and Gulf plan to invest \$900 million in a plant that will produce more than twice that amount. Two tons of tar sand produce about one barrel of crude. About the same amount of shale also produce a barrel of oil. But production difficulties in the arid Rocky Mountains mean that there will be long lean times before this source produces large quantities of oil. The cost of these synthetic crudes lies between \$4 and \$7 a barrel at 1970 prices.

Sir Peter Kent, Chairman of the Natural Environment Research Council and a former exploration manager with British Petroleum, warned of the difficulties that have already occurred in bringing North Sea Oil ashore. Pipelines are being laid at twice the usual depth for offshore oil in a stormy stretch of sea and "delays may very well arise".

Happy Hundredth

SIR RICKARD CHRISTOPHERS is 100 next Tuesday, November 27.

He started his scientific career in 1898 as a member of the Malaria Commission, jointly appointed by the Royal Society and the Colonial Office. Ronald Ross had just published his classical work on the mosquito as vector and Christophers, with his deep understanding of insects, was able to exert an enormous influence on the study of diseases borne by mosquitoes. He worked largely in India until 1930 and then returned to London to continue at the London School of Hygiene and Tropical Medicine. On retirement in 1938, he moved to Cambridge and spent part of the war working on insect repellents. From his reports to the Malaria Committee (1900-02) to his 700-page volume *Aedes aegypti*—the Yellow Fever Mosquito (1960) his publications have been of the greatest distinction.

Sir Rickard finally moved to Dorset in 1963 where he spends much of his time gardening. A full tribute appears in *Trans. R. Soc. trop. Med. Hyg.*, 67, 729 (1973).