in 1959, there were about 40 participants listening to 14 papers; in 1964, there were 160 participants who heard 56 papers; this year 115 papers were presented to an audience of over 400 participants from 36 countries and five international organizations and the meeting had to be extended from five to eight days. Incidentally, the proceedings of the first two symposia are among the bestsellers of the Agency's publications; the proceedings of the third will be available in spring 1969.

Scintigraphy is actively pursued in many developing countries as well as those which are highly industrialized. Some have made their first acquaintance with the method through the Agency's technical assistance and research contracts. Work is also conducted at the Agency's own laboratory to make comparisons between the performance of instruments and to standardize their response.

GAS-COOLED REACTOR DESIGNERS LOOK TO THE FUTURE

In little more than ten years nuclear power stations will be producing nearly thirty times more electricity than now. Growth in demand will continue. Designers of gas-cooled reactors evolved from those which first led the way are confident of their ability to help meet future requirements.

Advanced and high temperature gas-cooled reactors. These are part of the evolution from the original reactors using natural uranium in graphite with carbon dioxide as a coolant which provided the first large-scale production of electricity from nuclear sources.

Advocates of the newer versions of gas-cooled systems were able to present their reasons for confidence at an Agency symposium devoted to the subject and held at Julich, Federal Republic of Germany, at the end of October. Nearly 400 of them attended, about twice the number originally expected, drawn from 24 countries and seven international organizations.

Discussions centred to a large extent on experience obtained with the host country's AVR (Arbeitsgemeinschaft Versuchreaktor) which started operation in 1966 and has been producing up to 15 megawatts of electricity; the European co-operative project DRAGON, operating since 1964 with a maximum heat output of 20 megawatts; and the USA station at Peach Bottom, Philadelphia, producing 40 megawatts of electricity and operative since 1966. Reference was also made to the UK advanced gas-cooled reactor, now being built into new large-scale power projects.

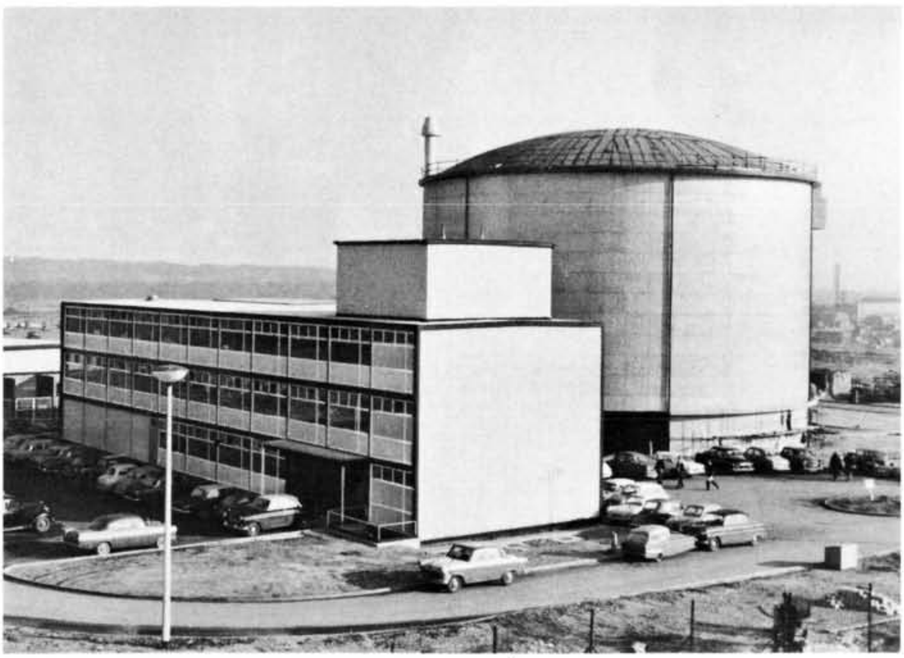
REDUCING COSTS

It became clear that a number of features have been developed contributing to future safety, efficiency and economy, and it was claimed that the use of gas turbines to generate the power could reduce capital costs by as much as 15 per cent. Helium and carbon dioxide are being considered for this purpose.

One of the notable advances has been a method devised in DRAGON and now adopted for many other reactors, of coating particles of atomic fuel with carbon, or silicon carbide, or both. These coatings prevent fission products created during reactor operation from escaping. This has been

---

Photo of the DRAGON reactor site at Winfrith Heath, UK. Built by international collaboration between Austria, Denmark, Norway, Sweden, Switzerland, UK and the EURATOM Commission, its operation since 1964 has provided valuable information for future planning. (Photo: UKAEA)

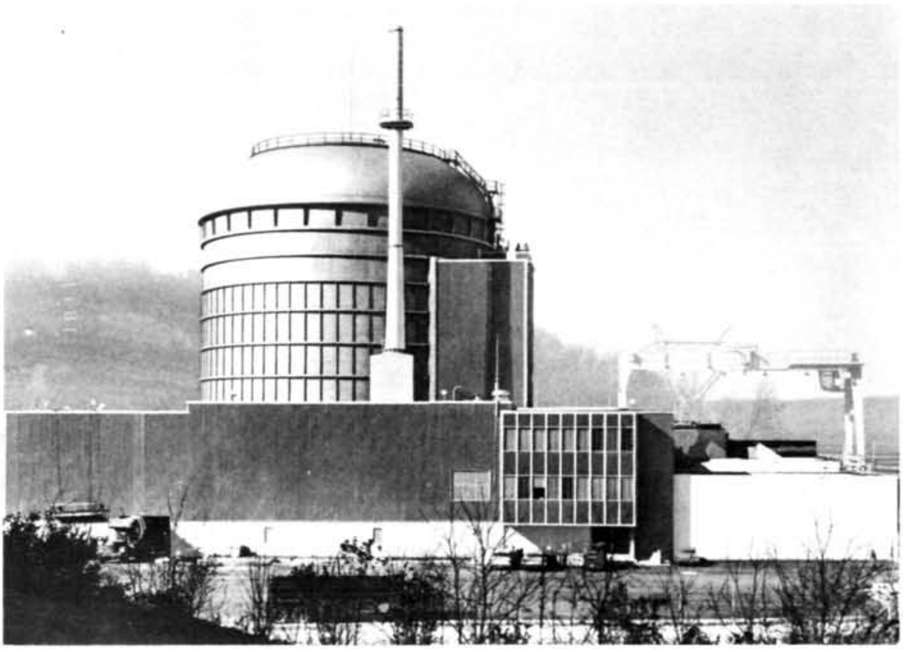


shown by tests in DRAGON at temperatures reaching 2 000°C, far above the expected maximum operating temperature of 1250°C.

Dr. Joachim Pretsch, Head of the Division of Nuclear Research and Computer Techniques in the German Federal Republic's Ministry of Scientific Research, forecast at the beginning of the symposium that advanced and high temperature gas-cooled reactors will play a large part in future power generation. New and advanced designs, use of gas turbines, improvements in components, equipment, fuel elements and material were leading to significant and exciting advances. More attention would undoubtedly be given to problems of the fuel cycle.

Dr. Bernard Spinrad, Director of the IAEA Division of Nuclear Power and Reactors, while welcoming the great interest in the subject, reminded the participants of two significant points. One was that owing to poorer heat transfer than in liquid cooled reactors, fuel in gas-cooled reactors must be run hotter to achieve the same performance; the other was that gas-cooled reactors had no easy reservoir of coolant to remove large quantities of heat by natural convection in emergency. These disadvantages were, however, compensated by better compatability of gas coolants with reactor materials, and by low neutron absorption. Judging by the competitive position achieved, the challenge was being met.

General view of the 40 MW high-temperature gas-cooled reactor power station at Peach Bottom, USA. It has been operating since 1966. (Photo: General Dynamics, USA)



Considerable attention was given during the discussions to safety requirements, and a warning was included that effort must be devoted to ensuring high performance of all engineering equipment at the same time as continuing unremitting attention to nuclear safety aspects.

Experience reported from Peach Bottom was that fuel performance was good; a large-scale power station is to be based on this system.

In the AVR, coated particles are incorporated in fuel spheres six centimetres in diameter which circulate throughout the reactor. Construction of a new 300 MW station in the Federal Republic of Germany using AVR as the basis is expected to begin in next year. Another smaller station with a high temperature gas cooled reactor is being built to demonstrate the use of a helium gas turbine.

Operating and building experience, new and advanced designs, economics and future potential were among other subjects considered.

For the final session a panel of participants was brought together under the chairmanship of Dr. Spinrad to assess and comment on the information received during the week. Those taking part were Professor K. Wirtz (Federal Republic of Germany), C.A. Rennie (ENEA, former Director of the Dragon project), B.E. Eltham (UK) and Donald B. Trauger (USA).

In Eltham's view the UK advanced gas cooled reactor was an essential historical step in gaining higher reactor rating and temperatures. He believed it to be the safest type currently available at competitive cost, and it had opened the door to urban siting. In fact the latest order placed in UK was for such a station close to a large town. Gas-cooled reactors were continuously developing and designs were available for small, medium and large sizes. Eight advanced gas cooled reactors currently under construction in his country were each rated at 625 megawatts.

It was clear, according to Rennie, that commercial designs for high temperature reactors were now available and that tenders could be made in the near future. Helium technology seemed to be accepted and there were no problems that could not covered by development. The use of prestressed concrete pressure vessels meant that siting near urban centres could be considered, and reduced cooling water requirements was an advantage. The general message he had obtained on fuel was that coated particles were in a satisfactory state of development, and current tests indicated that at maximum operating temperatures of 1250°C there would be some margin available. Further development work on high temperature reactors would mainly be on fuel testing, and this required financing. Dragon was going on as an international project and there was a considerable amount of work in Germany and in USA. He considered that the HTR could be regarded as ready for commercial exploitation; orders could be placed now in the confidence that fuel testing and development will be completed in adequate time.