

0.6 inches in diameter and 19.5 inches long, made of dense uranium dioxide in thin zirconium-alloy tubes. Heat is taken from the fuel directly by heavy water that passes at 560°F to the steam boiler, where normal water is raised to saturated steam at 483°F and 38 atmospheres. These details show that the design represents a considerable advance over that originally conceived in 1956, and the improvement bears promise that continued progress will lead to costs well below the economic target. As examples of the advance, it may be noted that, for the same electric-power output, the total heat production of the reactor has been brought down from 790 to 700 megawatts, the efficiency of the steam cycle itself has risen from 27.9 per cent to 33.3 per cent, and the length of fuel rod has been reduced from 86 to 30 kilometers. The prospective fuelling cost has dropped from 1.85 mill/kwh to 1.0 mill/kwh. On the other hand, no general reduction has been achieved in the capital-cost estimates, which remain in the range of \$300 to \$400 an electrical kilowatt for the whole plant. However, a reduction is expected now that manufacturing experience has been gained that can be used in future construction. Even greater reductions in unit power cost will result at Pickering from the increase in the capacity of the reactor to 500 megawatts of electricity and the incorporation of several such units in a large generating-station.

An evaluation was presented at the third United Nations Conference on the Peaceful Uses of Atomic Energy at Geneva in September 1964 of cost estimates of several preliminary designs of large power reactors using heavy water as moderator. These designs represented types for which development work was well advanced. The differences lie in the choice of heat-transfer fluid or "coolant" and the steam cycle. Basically, there are three coolants: heavy water, ordinary or light water, and an organic liquid. The heavy water can be under pressure to prevent boiling or to allow some boiling. Light water must boil or must be in the form of "fog" or "wet steam". The organic liquid must not boil. All types have excellent economic promise and it was decided to develop the boiling light-water type, chiefly for two reasons: (1) By taking the steam direct to the turbine a boiler or heat-exchanger is eliminated and the efficiency is raised. (2) The second advantage is a relaxation of the strictness of control of leaks needed with hot heavy water, both because of its cost and because of the toxicity of the tritium it contains. Some development of the organic liquid system continues under a new agreement with the United States in support of its programme to develop such a system for water desalination as well as for power.

Most of this development work centres on establishing the properties of materials for the arduous environment of high temperatures, and radiation effects affecting the solids and the fluids. In ordinary engineering, the three parameters of stress, temperatures and time lead to complex analyses, especially when corrosion and atomic diffusion are active. In reactors, irradiation is a fourth and major parameter. Thus, materials development still calls for a major scientific and engineering programme of studies.