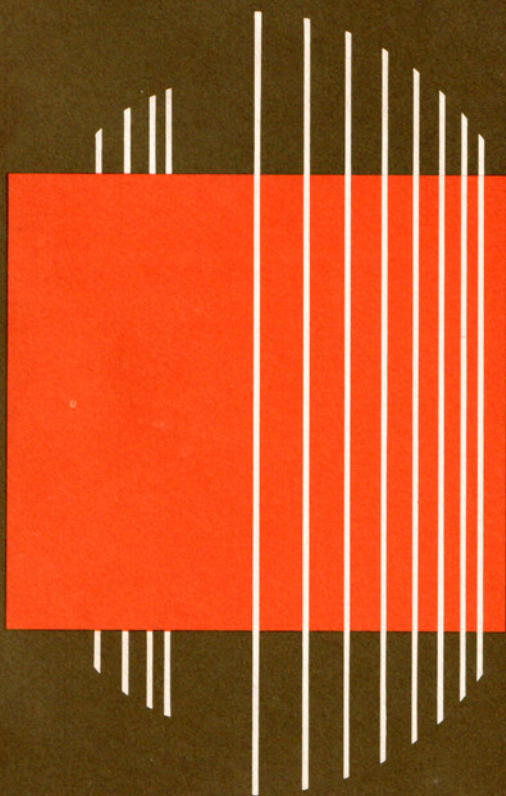


The fast reactor



Why do we need fast reactors ?

Towards the end of this century world production of oil and gas, including Britain's contribution, is expected to decline. Oil now provides most of the world's energy, and it is essential for transport and for the production of chemicals and fertilizers. Britain and the world have large reserves of coal but these will be increasingly required for other uses besides burning in power stations. "Renewable" resources such as solar energy are unlikely to contribute very much on the relevant time-scale.

Nuclear power stations based on uranium-burning "thermal" reactors have generated electricity in Britain since 1956. They now produce about 13% of all our electricity and do so more cheaply than stations burning coal or oil. Besides being well established as a safe, clean and comparatively cheap source of electricity, nuclear power can help to avert a long-term fuel shortage, and thus make a major contribution to the maintenance and improvement of living standards here and throughout the world.

World reserves of uranium however are limited: when used in thermal reactors (which operate predominantly on the very small — 0.7% — fissile component of natural uranium) they are not enough to meet the world's requirement very far into the next century.

"Fast" reactors — which get their name because they use fast neutrons whereas in thermal reactors the neutrons have to be slowed down — produce energy by burning the plutonium which arises as a by-product of the operation of thermal reactors. At the same time fast reactors can gradually convert non-fissile uranium (which forms 99.3% of the natural material and which thermal reactors cannot burn) into additional plutonium. Thus by progressively producing and burning plutonium, fast reactors can extract from a given quantity of natural uranium 50 to 60 times as much energy as can the thermal reactors now in operation.

In Britain alone we already have in stock some 20,000 tonnes of non-fissile "depleted"

uranium remaining from the operation of thermal reactors. Used in fast reactors this could deliver energy equivalent to some 40,000 million tonnes of coal, that is to say about 400 years' supply at the present rate of extraction. Expressed in terms of oil this is equivalent to 23,000 million tonnes — more than five times as much as is expected to be extracted from the North Sea oilfields.

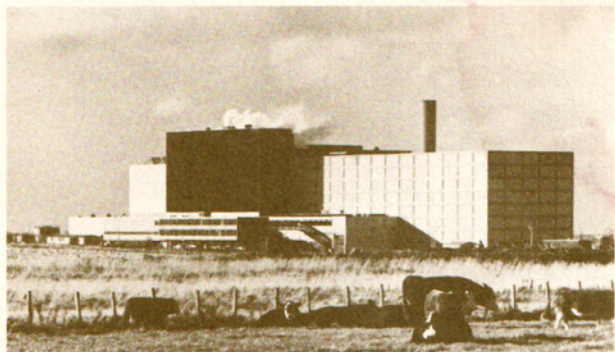
If Britain implements a programme of building both thermal and fast reactors, then less than half a million tonnes of crude uranium oxide would be enough to generate all the electricity we need for several hundred years. Without fast reactors an equivalent programme of thermal reactors alone would use up this same amount of uranium every 15 or 20 years, until a new source of energy became available. Even if this amount could be obtained the competition for the world's limited reserves of uranium could push the price up to levels determined by highly priced fossil fuels. Thus the UK would again be presented with a large and increasing fuel import bill.

Fast reactors thus offer to the world, and particularly to countries like Britain which have to import uranium, both strategic and economic advantages.

What experience have we had?

The potential advantages of the fast reactor were apparent from the earliest days of nuclear energy. At that time supplies of uranium were scarce, and the importance of the fast reactor's ability to make the maximum use of nuclear fuel by breeding and burning plutonium was recognized: development of the fast reactor was regarded as an essential long-term part of Britain's nuclear power strategy. The advantages of the fast reactor were recognized similarly in other countries.

Serious consideration of the engineering of fast reactors in the UK dates from 1951. The first small experimental fast reactor in Britain was built at Harwell in 1954 for research purposes. The following year a larger, but still low-power, research reactor was built, also at Harwell. These reactors were used to make practical checks on the physics of the fast reactor system.



The Prototype Fast Reactor, Dounreay, Caithness.

To explore the engineering aspects of fast reactors, an early decision was taken to build an experimental fast reactor power plant at Dounreay in the North of Scotland. This Dounreay Fast Reactor (DFR), designed and built by the United Kingdom Atomic Energy Authority, started operating in 1959 and was brought up to its full electrical output of 15 megawatts over the next few years. It was shut down in March 1977 after generating more than 500 million units of electricity during its working life, its vital role in the development of fast reactors having been completed.

Meanwhile, using information derived from the construction and operation of DFR, the Authority carried out design studies of reactors of the capacity required for modern electricity generation. A flexible zero-power fast reactor (ZEBRA) was built at Winfrith to study the physics of full-sized reactors.

All this work gave confidence to the Authority to proceed with the next step — the building of the 250 megawatt Prototype Fast Reactor (PFR) at Dounreay. This incorporates features shown to be desirable in larger commercial reactors: for example the fuel is very similar in size and design to that which will be used in commercial reactors. PFR was completed in 1974 and reached full thermal power in 1977.

Similar experience has been gained in other countries. Two reactors comparable in size with PFR have been built, one in the USSR and one in France (PHENIX), and work is being done on experimental plants in other countries. France, Germany and Italy are collaborating in

the building of a 1,200 MW fast reactor known as Super-Phénix, while Germany, Belgium and Holland are working on the 300 MW reactor, SNR 300. In the USSR a 600 MW fast reactor (BN 600) is nearing completion, and the United States has a major research and development programme on fast reactors.

How safe is the fast reactor?

In over 25 years of generating electricity by nuclear power in Britain, including 20 years of fast reactor operation, the nuclear industry has had an outstanding safety record.

Fast reactor safety depends on the same principles as those used in thermal reactors, which are:—

- (1) Design, construction and operation to the highest engineering standards.
- (2) Continuous monitoring of the reactor by a range of different instruments. These are arranged as independent systems and any departure from steady operation is detected and the reactor automatically and immediately shut down. The instruments are designed to "fail safe" — that is, failure of the instruments themselves results in automatic shutting down of the reactor.

These inherent design features and protective systems make the probability of a significant accident less than one in a million years of reactor operation. Even so, such "hypothetical" accidents have been studied by imagining a succession of faults and failures leading to the melting of fuel and increases in energy release. A commercial reactor would be housed in a vessel capable of containing a hypothetical accident in this class. There is no possibility of a nuclear reactor, fast or thermal, exploding like an atom bomb.

The highly-active liquid waste arising from the reprocessing of fast reactor fuel is not significantly different in kind or amount from that from thermal reactors and the same storage and disposal techniques will be used.

The safety of nuclear power plants is assessed by the Nuclear Installations Inspectorate (which is quite independent of the design, construction and operating organisations) and only on the basis of its advice is a licence to operate granted. The Inspectorate has said that: "Given,

as seems reasonably likely, a successful outcome to the development work now in hand or envisaged, there should be no reason why a commercial fast reactor cannot be made safe enough to be licensed by the Inspectorate."

What about the problems of plutonium?

The process of converting non-fissile uranium 238 into plutonium enables fast reactors to produce more plutonium than they consume. Nevertheless because they use it as a fuel, their nett production of plutonium for a given output of energy is less than that of current thermal reactors. Furthermore, fast reactors can be operated in such a way as to reduce the rate of plutonium production, or actually to use it up.

The nuclear industry has some 25 years' experience in reprocessing used fuel to extract plutonium, and in handling, storing and transporting the latter safely. The use of fast reactors to burn plutonium ensures that much of this material is located inside reactors where it is very secure. Plutonium is transported in massive containers which would be very difficult to hi-jack or breach. It would also be possible, if necessary, to keep the movements of plutonium to a minimum or to transport it in a form which would provide additional safeguards against terrorists. The means taken to safeguard plutonium to prevent its illegal diversion are regularly reviewed. The Gov-

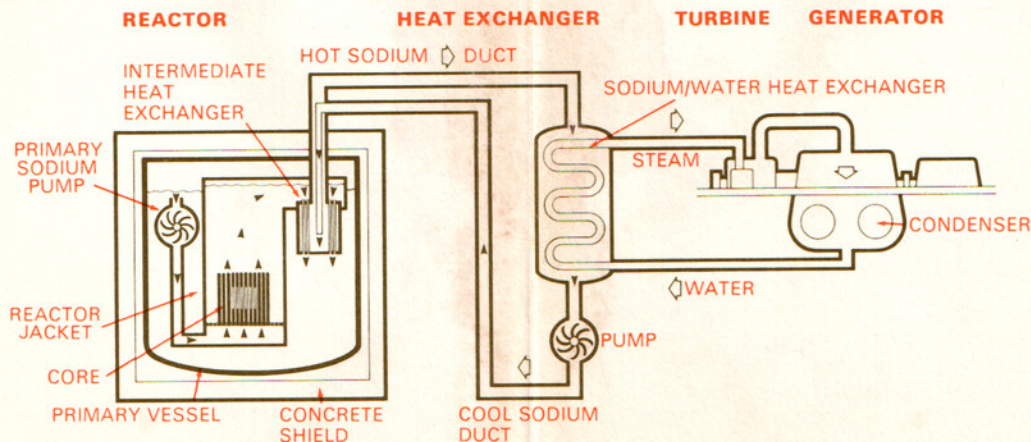
ernment do not believe that the extension of nuclear power on the scale envisaged would involve measures that would interfere with civil liberties.

Where do we go from here?

The next logical stage in the step-by-step development of the fast reactor in Britain would be the building of a commercial demonstration reactor — CDFR — of about 1,300 megawatt size. The Government have promised a public enquiry to consider among other things the broad implications of a decision to proceed with this project.

As currently envisaged, CDFR, besides generating large amounts of electricity which could considerably offset the cost of the project, would provide experience in the manufacture and assembly of full-sized components, and demonstrate the safe and reliable operation of a large fast reactor power station. This experience is needed if the UK is to have the fast reactor available as an option for large-scale electricity generation towards the end of this century, at a time when oil and natural gas are expected to be in increasingly short supply.

The diagram shows how molten sodium transfers heat from the reactor to intermediate heat exchangers, from which a separate sodium circuit carries it to the sodium/water heat exchangers where steam is raised for the turbines.



Further information on atomic energy and its applications can be obtained from:

**Information Services Branch
UK Atomic Energy Authority
11 Charles II Street
LONDON SW1Y 4QP**

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**Press and Publicity Office
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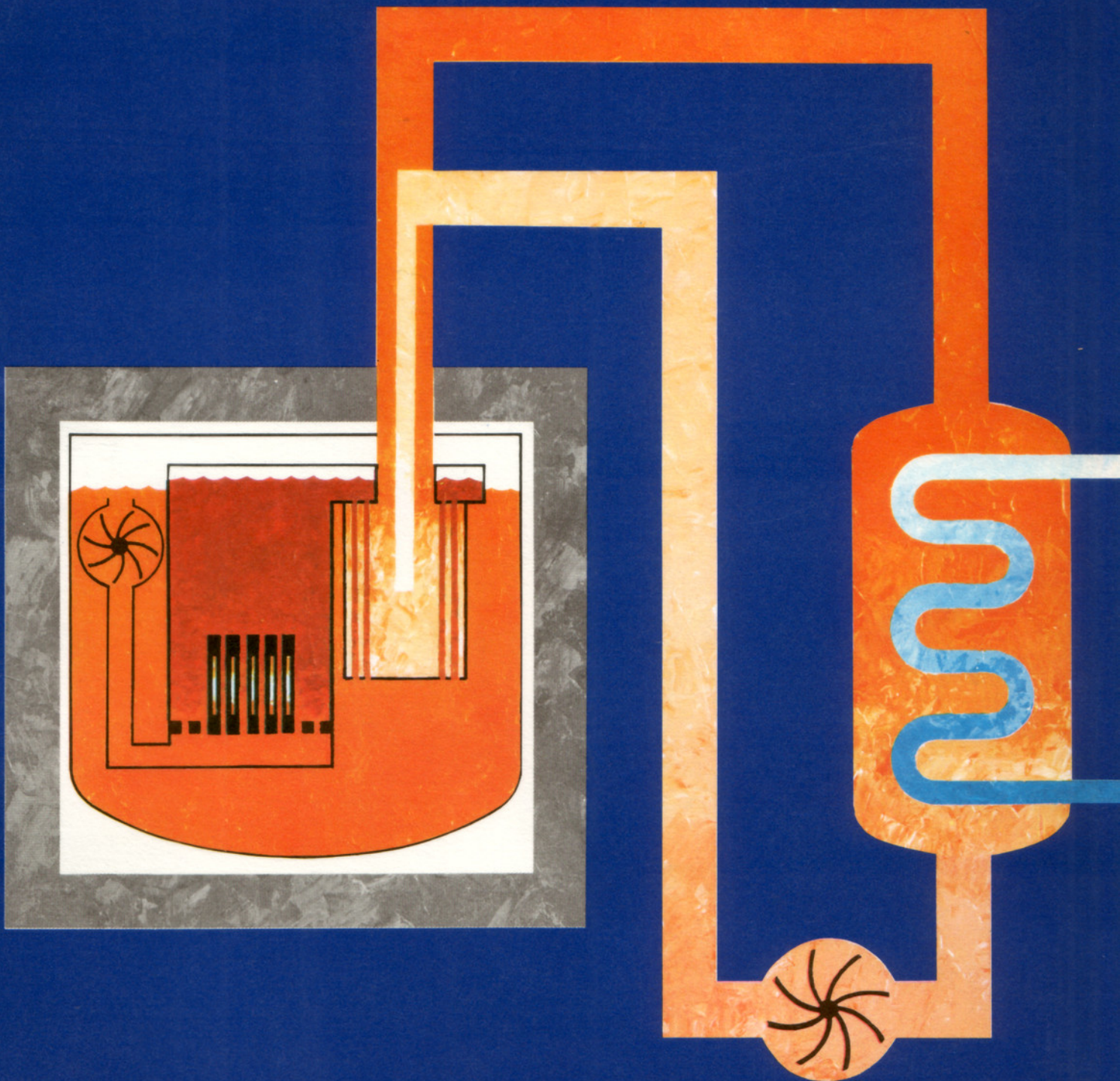
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