Breeders Move Front and Center

by Carl Behrens

The market for nuclear electric power reactors is booming, and the Atomic Energy Commission, although happy, is afraid that it may boom itself right out of uranium—or at least cheap uranium.

That's why the AEC is spending most of its reactor money now on an advanced type that will not only conserve uranium but actually produce more fuel than it consumes. And industry is just as enthusiastic about the new type of breeder reactor as the government agency.

The reactor which is attracting the attention of forward-looking industry people is known in the jargon of the nuclear world as the LMFBR: the Liquid Metal Fast Breeder Reactor. The words "fast breeder" give the LMFBR its appeal. They reflect a much more efficient way of using the fission of uranium atoms to produce energy.

When a uranium atom of a fissionable type is struck by a neutron, two things happen. First, the atom's nucleus is split apart, releasing energy and producing other entirely different elements as fission products. Second, more neutrons are ejected from the split nucleus, and these neutrons can strike other atoms, causing them also to split, or fission. If enough neutrons are released at each fission, a chain of reactions can be sustained as long as there are fissionable atoms to feed them.

In the conventional type of reactor, such as is now being built for commercial use, the fissionable uranium is exhausted and eventually the chain of fissions is broken. This happens when too many neutrons are absorbed by fission products which cannot split further.

In a breeder reactor, available fuel is not exhausted because an added feature of nuclear fission is utilized. Some atoms are present in the nuclear fuel which are not naturally fissionable but which can absorb neutrons in such a way that they change to elements which are fissionable. An example is U-238, a form of uranium which does not split in a nuclear reaction, but which is more common than the fissionable U-235. Although it will not fission, U-238 can absorb a neutron to become U-239, an unstable element which decays in several days to a new element, plutonium. The new element, Pu-239, can fission.

This type of process can occur in all reactors, but in those being built today it does not happen often enough to regenerate the fuel supply. However, if new fissionable material can be produced faster than the original material is split, then the reactor will breed its own fuel supply.

The LMFBR is designed to be self-sustaining once it is started—it breeds the fissionable material it requires to keep operating. Even more, it breeds fast enough to fuel new reactors with the surplus of fissionable material it produces.

Appealing as the breeder reactor concept is—it looks like man's first successful attempt to get something (fissionable material) for nothing—there are serious problems involved in breeders which do not occur in the more conventional type of reactor being built today.

The breeder must carry out three separate functions. First, it must produce heat through the fission of heavy atoms. Second, it must produce neutrons to continue the chain of fissions. And third, it must breed new fissionable material through the absorption of neutrons by non-fissionable atoms. These three functions require conditions which do not always match.

The heat-producing fission is brought about most easily by neutrons that are moving slowly. For this reason, in contemporary reactors a moderator—like heavy water or graphite—is mixed with the fissionable fuel to slow the neutrons down. But slowing-moving neutrons are more easily absorbed by fission products or wastes, and fewer are then available to continue the chain and to breed new material.

So breeders do not use a moderator. This means that high-speed neutrons which ordinarily zip right through, must somehow be led to cause fissions, as well as to produce new material. This can be done by providing a higher percentage of fissionable atoms in the fuel, but the proper concentration must be developed by experience.

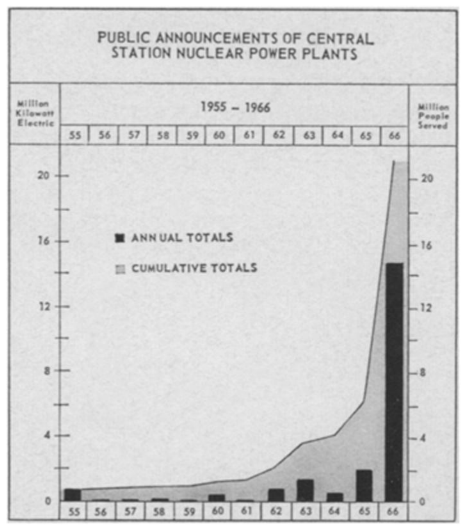
Another problem is that the high-speed neutron radiation causes much faster deterioration of the walls of the nuclear reactor. The development of materials which can tolerate the effects of high irradiation over many years has just begun.

In addition, the new type of breeder uses a liquid metal, sodium, to transfer the heat of the fission to the steam turbines which produce electricity. The techniques of handling, pumping, and conserving liquid sodium must also be developed.

These problems mean that breeders like the LMFBR will take a while to develop. The U.S. has gained experience since 1963 at the Enrico Fermi plant at Lagoona Beach, Mich., which uses sodium cooling but is not a breeder. Despite this work, the AEC estimates that it will be late 1969 or 1970 before work on a demonstration plant can be begun, although industry would like to begin a prototype much sooner.

In the meantime, expansion of the conventional type of non-breeding reactor, using boiling water or pressurized water to drive the turbines, continues apace. Although at present less than 2,000 megawatts of electricity are produced by nuclear plants, by 1972 reactors under construction or planned now will produce almost 24,000 megawatts. This is about 10 percent of the total U.S. consumption of electricity today.

Most of this increase will be obtained from reactors with much larger capacity than any operating today, but the design of the new plants is not very different from the ones built in past years.



AEC

1966—expansion year for nuclear power.

This tremendous expansion, most of it in the last year, promises to eliminate the surplus of uranium which has been built up since 1955. The supply of uranium that can be mined cheaply is limited and after that is exhausted the cost of uranium could go up sharply. This is why the AEC and industry are both pursuing what looks like nuclear perpetual motion.