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Glamorous Nuclear Fusion

Viewed from a distance, energy from the fusion of light nuclei is a glamorous concept. Advocates have talked of obtaining unlimited amounts of cheap, clean energy from the virtually inexhaustible deuterium of the oceans. But looked at closely, deuterium fusion is far from practical application; if achieved it will be costly, and it will create large quantities of radioactive substances.

The radioactivity associated with fusion arises when neutrons produced by the reaction of deuterium with deuterium or tritium collide with wall and structural materials. In the generation of a given amount of energy considerably more neutrons are produced by fusion than by fission. This is true whether the fusion occurs in a magnetically confined plasma or is induced by lasers. Thus, shortly after a fusion device begins to generate energy in substantial amounts, the inner walls will become so radioactive as to prevent direct contact by workmen. With more lengthy exposures a radioactive waste disposal problem will ensue.

Neutrons undergo many nuclear collisions before they are absorbed. These encounters damage the crystalline structure of solids. In a practical fusion device each atom of the containing inner wall would be drastically displaced many times a year. Moreover, the very fast neutrons from deuterium-tritium reactions create hydrogen and helium within lattice structures, leading to embrittlement. These damaging radiation effects would be likely to necessitate replacement of highly radioactive materials, requiring the use of complicated remotely controlled equipment.

To obtain a useful rate of fusion in the easiest case—deuterium plus tritium—energies of 10 kiloelectron volts, corresponding to 100,000,000°C, are required. The fusion device that is currently receiving most funding is the tokamak. This machine employs magnetic confinement to keep the hot plasma away from metal walls. To achieve production of practical amounts of energy, a very large volume of plasma and a correspondingly large magnetic field are required. But more than just any large magnetic field is needed and the problems of confining plasma of a useful density may never be solved. During the past 20 years, some of the world's most talented physicists have worked toward practical fusion. The outstanding lesson that they have learned is that hot plasmas are difficult to confine.

The U.S. contingent in fusion research has been supported with a total of about $800 million. Thus far the results, though moderately encouraging, are not impressive—to produce an output of 1 watt of fusion power requires an input of about 10^6 watts. To reach a break-even condition will apparently require building a succession of very large, very costly devices employing superconducting coils. The total cost of attaining a 10-megawatt output by a fusion unit in 1990 has been estimated to be $10 billion. This is in contrast to a cost of $100 million to reach the same energy output by a solar device or a breeder reactor.

Moreover, the tokamak device does not produce power continuously but must go through a cycle during which output falls to zero. Utility executives have enough headaches without trying to cope with that kind of source of power.

Nuclear fusion has been hailed as one of the world's three major long-term energy options along with breeders and solar energy. Ultimately, its great potential may be harnessed and this nation should continue to support efforts to reach the goal. However, thus far fusion has been like a pot of gold at the end of a rainbow. The beauty of the rainbow should not dazzle us into depending on riches we may never see. Nor should the glamor of the challenges of the high technology of fusion be allowed to keep attention away from such humdrum measures as conservation and the development of a practical photosynthetic energy source.—PHILIP H. ABELSON

This editorial is based largely on material that has appeared in *Science*, especially the articles by W. D. Metz in the issues of 25 June and 2 July.