APPENDIX A

A BRIEF OUTLINE OF FUSION

Fusion is the joining together of two nuclei of light elements to form a heavier element. A small decrease in the total mass of the system results in the release of a large amount of energy ($E = mc^2$, where m is the mass destroyed and c is the velocity of light). The fusion reaction of current interest involves the fusion of deuterium (D) and tritium (T), two isotopes of hydrogen, to form a helium atom and a neutron. At a later stage, fusion of two deuterium atoms may be proved possible as an energy source.

A number of technological problems have to be resolved before fusion becomes a practical source of energy. Temperatures in excess of 50,000,000°C are necessary to overcome the repulsive forces between the charged nuclei of deuterium and tritium. The reactants must therefore be confined to prevent contact with the vessel walls. The problems associated with attaining such extreme temperatures, confining the reactants, and developing suitable power plant materials are all subjects of concentrated research and development efforts.

Several methods have been proposed for restraining the reactants from contact with the vessel walls. The two most promising at present are magnetic confinement and inertial confinement. At the extreme temperatures required for fusion, the reactants exist in a charged particle state ("plasma"), rather than as neutral atoms, so that, in principle, confinement can be achieved by suitably shaped magnetic fields. Various types of magnetic confinement machines are currently being developed, but the largest research effort is being carried out on toroidal machines. Inertial confinement uses lasers, electron beams, or ion beams to deliver large amounts of energy, in very short pulses, to fuel pellets. The required energy must be delivered in a sufficiently short time that the fusion reaction can occur before the pellet expands as a result of the large increase in temperature.

Deuterium is a stable material found in about one part in 7000 in ordinary hydrogen. Its oxide, D_2O, called heavy water, is being produced in tonnage quantities in Canada. Tritium is not found in nature. A fusion plant would manufacture its own supply of tritium by allowing the fusion neutrons to be captured in lithium. An atom of lithium is needed for each atom of tritium so that effectively the D-T fusion reaction needs a supply of lithium. This appears to be sufficiently plentiful to provide for possible world fuel requirements for several hundred years.

In the first fusion power plants the only fuels would be deuterium and lithium. Such plants would produce no fission products, the only radioactive material involved is tritium. While the structural materials in the plant would become radioactive, no particular problem is presented during normal operation. These power plants operate by absorbing the energy radiated by the reacting plasma in a "blanket" wrapped around the reaction region. The hot blanket is used to heat a working fluid which could drive a gas turbine which, in turn, drives an electrical generator.