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THE SOLAR-AMMONIA SYSTEM

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This paper describes the solar-ammonia process - conceived by Carden[1,2] - for large scale generation of power from solar energy using the reversible ammonia reaction - $2NH_3 \rightleftarrows N_2 + 3H_2$ - a distributed array of solar collectors, and a central generating system, as shown schematically in Figure 1. As presently envisaged, a power plant based on this reaction will involve up to about 100,000 tracking paraboloidal mirrors, each of 10 m^2 nominal area. The solar energy concentrated at each focus is absorbed at 700°C as the endothermic heat of dissociation of high pressure (300 atm) ammonia. The dissociation reaction occurs in catalytic reaction chambers positioned at the focus of each paraboloid.

A pipe network enables the gases to pass from the mirrors to the separator - where the product gases are separated from any residual ammonia - and to the central processing plant, where recombination of the nitrogen and hydrogen occurs by the standard Haber process for manufacturing ammonia. In the synthesis catalytic reaction chamber, the solar energy is recovered as the exothermic heat of reaction. A steam generator coupled to a conventional turbo-alternator may be used to produce electricity.

The reactants are continuously circulated between the mirrors, the separator, and the central terminal. At 300 atm pressure, small diameter pipes - c. 5 mm I.D. - are sufficient for transferring the reactants between each mirror and a trunk line. Counterflow heat exchangers in each mirror and at the central processing plant enable the reactants to be transferred at ambient temperature.

It is envisaged that a small computer will direct the two-axis tracking of the paraboloids, each equipped with actuators for controlling elevation and azimuthal movements. Three phototransistors behind a shadow disc sense the orientation relative to the sun. During correct orientation, each phototransistor lies in the penumbra of the disc's shadow and registers the same intensity of sunlight. When the paraboloid is misoriented, the phototransistors register different intensities. The computer records the intensities of the phototransistors during interrogation periods and computes and sets actuator speeds.

The high capital cost of a solar power plant implies a necessity for continuous power production; hence, storage of energy for use during the absence of sunshine is an essential component. Storage is an advantage of the solar-ammonia process; eg the high pressure nitrogen/hydrogen gas mixture may be stored in underground reservoirs, such as disused oil wells or geological aquifers. For storage of a 3-month supply of the nitrogen/hydrogen gas mixture at 300 atm for a 50 MWe power station, a space of about 10^7 m^3 is required.

Cost of electricity - produced continuously - from a solar-ammonia system is estimated at about 7¢ per kWh - competitive with present electricity costs in many remote areas. To reduce the cost of electricity, the synthesizer of the solar-ammonia system can be used to produce simultaneously both electricity and ammonia for external consumption, so that profits from the sale of ammonia subsidize the electric power costs; thus, as the market price of ammonia increases (with the price of crude oil and naphtha), the price of electric power from the solar ammonia process will decrease.

1. P.O.Carden, A Large Scale Solar Plant Based on the Dissociation and Synthesis of Ammonia, Energy Conversion Tech.Rep.No.8, Research School of Physical Sciences, The Australian National University, Canberra, Australia, November 1974.

2. P.O.Carden, Energy Corradiation Using the Reversible Ammonia Reaction, Solar Energy, accepted for publication.

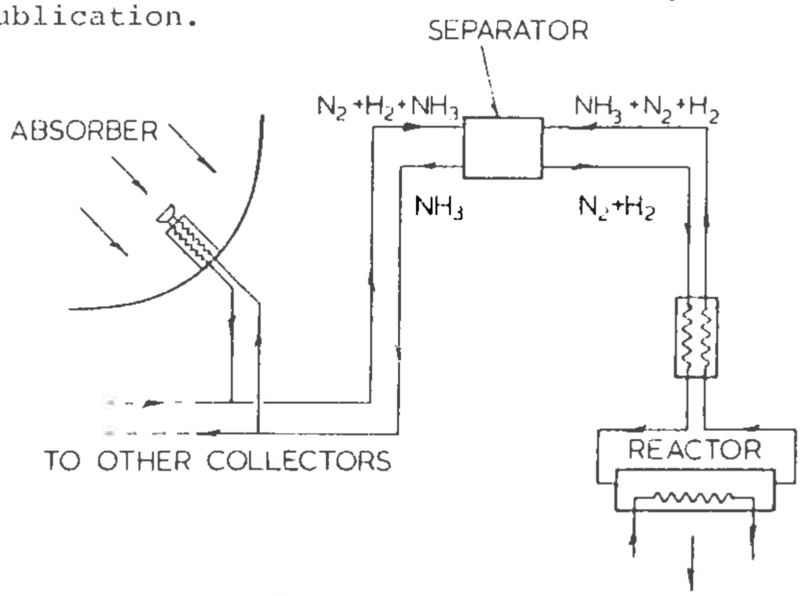

Fig.1. The solar-ammonia system