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NASA TECH BRIEF

Feasibility Study of Wireless Power Transmission Systems

A study has been made of the feasibility of using microwave or laser energy for wireless transfer of power from a manned, Earth-orbiting central station to unmanned astronomical substations. This is a recent conception, and details of a power-transfer system have not been established. Therefore, the possibility of wireless power transfer is judged on the basis of the state of research and development in power generation, transmission, and conversion.

Existing microwave power generation is more than adequate for the estimated 2 kW requirement of a satellite substation. Generators such as superpower Amplitrons have a laboratory output exceeding 400 kW of cw power at a wavelength of 10 cm. In an unoptimized power system (including generation, transmission, and conversion) with an overall efficiency of 18 percent, an Amplitron could supply power for several substations. Microwave power transmission would require better efficiency than is acceptable for present radar and communication systems. One idea for improving efficiency is to form a convergent beam in an ellipsoidal transmission "envelope." Calculations involving the relationship between antenna size and operating wavelength show that antenna size can be reduced as wavelength is reduced. However, generator efficiency also diminishes with shorter wavelength. The implication is that improvement of generator efficiency for operation at shorter wavelengths (less than 3 cm) would permit a significant reduction in antenna size. Direct conversion of microwave to dc power is a more recent development than power generation. Semiconductor diodes and close-spaced thermionic diode rectifiers are considered the most promising components for aerospace applications. A microwave power transfer system has already been used experimentally to operate a helicopter device; and a beam-riding system is under development. This is an attempt to use a microwave beam to control a distant helicopter as well as supply its operating power. The present availability and performance of microwave components and the progress being made in research and development point to the feasibility of a practical wireless power-transfer system for aerospace use within a few years.

Laser high-power development, being newer, is behind microwave technology. The highest power attained in the laboratory has been 7 kW, with a CO_2–N_2–He medium. Despite the short history of its development, however, power generation is progressing rapidly; the 7 kW output represents more than a threefold increase within the year. Laser power transmission and conversion still are in the research stage. One of the goals of research in power transmission is to obtain a long-lived refractor that will withstand high-power radiation. Lenses of doped germanium (Ge–Sb–Se) and of ultrapure germanium are being tested for this use. Laser energy has been converted to electric power by means of photovoltaic detectors. These are semiconductor diodes with p-n junctions of Cd–Hg–Te alloys, and can be made for efficient operation at the CO_2 laser wavelength. Calculations similar to those made for microwave antenna size show that transmission and receiving apertures would be much smaller

(continued overleaf)

for the laser beam. This offers a special advantage over a microwave system, which must compromise between transfer efficiency and antenna size.

Notes:

1. The feasibility study contributes to general knowledge of the state of the art and should be of interest to those concerned with future development of wireless power transmission systems for industrial and commercial applications.
2. Complete details may be obtained from:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B68-10309

Patent status:

No patent action is contemplated by NASA.

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