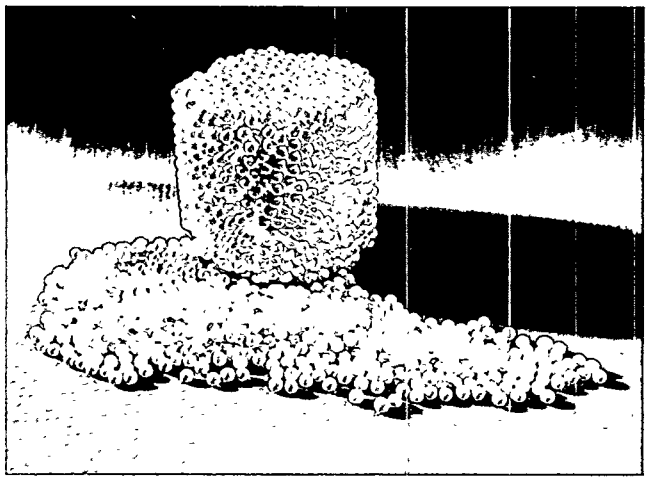
developed at the Brookhaven National Laboratory, uses low-cost optical detectors and common electronic devices. It includes a simple display that shows when the combustion air is set for the highest efficiency and indicates when the burner needs adjustment or servicing.

The oil-heat industry responded positively to the monitor. Cooperative field tests were conducted during the 1989–1990 heating season with funding from the Canadian Mortgage and Housing Corp. These field tests will continue during the 1990–1991 heating season, again with cofunding from the Canadian Mortgage and Housing Corp. Several manufacturers and fuel-oil supply companies have also expressed interest in the device, and opportunities for cooperative field tests are being explored. The next research stages will examine automatic control of the burner's air/fuel ratio, allowing the burner to compensate for seasonal variations in chimney draft, as well as dust and lint accumulation on the air-inlet passages.

Thin-Walled Hollow Spheres from Powders

There is great potential to reduce energy loss in homes and in industry by using improved, economical insulating materials. Through DOE-sponsored research, an innovative process was developed to fabricate small, hollow spheres (aerospheres) for use as thermal insulation.



An inexpensive, continuous fluid flow process produces a new type of thermal insulation consisting of thin-walled hollow spheres known as "aerospheres."

Aerospheres appear to be the best candidate insulation for very high temperature applications (greater than 1500°C) because of their durability and low cost. For lower temperature applications, aerospheres are also economical, noncarcinogenic, ecologically safe, and noncompressible over time. Their application as thermal insulators and structural materials is broad and includes use as room insulators; high-temperature insulators; fire proof materials; loose, free-flowing building shells; low-density structural fillers; plastic fillers for density control; and uniform-wall, closed-cell foams. Potentially, aerospheres may also be used as inert supports (catalysts, molecular sieves) and encapsulants for biological culturing.

The thin-walled hollow spheres are blown by a coaxial nozzle using highly volatile powder slurries. These liquid spheres are then dried in an updraft tower and subsequently fired to 1600°C to produce low-density, impervious shells. The thermal conductivity of these shells has been measured to be as low as 0.13 watts per meter-kelvin, and the production cost may be reduced with novel processing (under development) to approximately 50¢ per pound (compared with fiberglass fabrication costs at 45¢ per pound).

This innovative concept was used successfully to produce spheres from alumina, partially stabilized zirconia, ferrite, and Kaolin clay powder slurries. In addition to the flexibility of using different materials, this process allows the uniformity, density, and quality of the spheres to be controlled during their production. Spheres of high specific strength and viable thermal conductivity can be produced economically.

Modeling studies are under way to characterize the apparent thermal conductivity of beds of thin-walled, hollow ceramic spheres and to assess their energy-conserving potential. These studies will provide predictive models for property dependence on gas, gas pressure, temperature, sphere material, and sphere size. A data base will be developed to predict the behavior of new materials used for hollow-sphere processing. Development was expanded to include spheres composed of mullite, silicon carbide, silicon nitride, titanates, and metals.

Further development and characterization of these novel spherical insulators will yield alternative materials that are economical to produce and that have outstanding insulating properties. It is expected that these new insulators will have broad industrial and residential application.