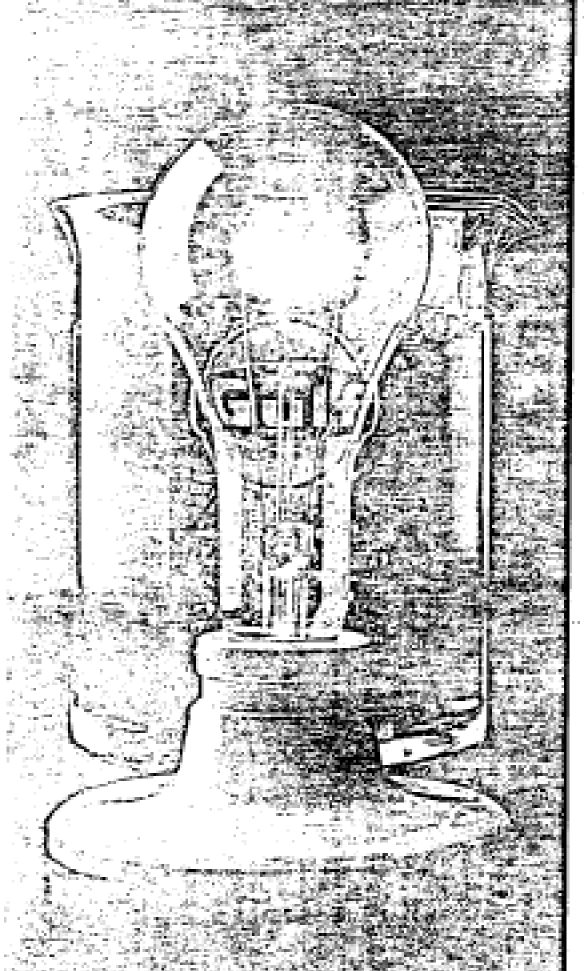
At Gulf, we're working on a way to light lights, cook meals, and heat houses with the energy stored in water.



"You probably remember from grade school science that water is two parts hydrogen and one part oxygen," says Dr. John Norman.

"Here at General Atomic Company, a subsidiary 50% owned by Gulf Oil, a project is under way to

"There are 326 million cubic miles of water on earth, and hydrogen in every drop—a natural energy reserve that won't run out." [illegible]

extract hydrogen from water for use as a fuel: for heating, cooking, or anything that now uses petroleum or natural gas.

"The extraction process is called thermochemical water-splitting. We know it works because we've done it. But it takes high temperatures – about 1600° F – so it's rather expensive.

"It may be the turn of the century before it becomes commercial. But it's an attractive idea. Hydrogen from a gallon of water has about half as much energy as there is in a gallon of gasoline.

"Hydrogen can be made into a liquid or gaseous fuel. It can be transmitted long distances more cheaply than electricity. And when hydrogen burns, it's converted back into water. Very tidy."

At Gulf, our first priority is to get all the oil and natural gas we can out of resources right here in America. But we're working on a lot of other ideas, too. Thermochemical water-splitting is one of them. We are also working on underground coal gasification, solar research, liquefied coal and other synthetic fuels, geothermal energy, and other alternative energy sources.

Basically the business we are in is energy for tomorrow.

Gulf people: energy for tomorrow.

Gulf Oil Corporation

(A4.)

SPLITTING WATER

The fuel of the future may be hydrogen gas, separated from water by artificial photosynthesis

by PAMELA WEINTRAUB

I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light....

—Jules Verne, 1874
The Mysterious Island

Like so many other of Jules Verne's writings, this prophecy may become reality. If the hydrogen on earth were readily accessible, it could become a major and virtually unlimited source of energy. Passed through fuel cells, it could generate electricity. Cooled and liquefied, it could serve as fuel for modified internal-combustion engines; in liquid form it contains two and a half times the energy of an equivalent weight of gasoline. And hydrogen has a great environmental advantage as a fuel: the product of its combustion is water.

But most terrestrial hydrogen is locked up, bound with oxygen in the form of water. Electric current, passed through water in a process called electrolysis, can break that powerful bond, releasing hydrogen as well as oxygen. But there is one [illegible] drawback: the amount of electricity [illegible] to produce practical amounts of hydro[illegible] prohibitively expensive. Nature has a [illegible] way. For hundreds of millions of years, plants have been splitting water [illegible] drogen and oxygen with chloroplasts, [illegible] cellular factories energized only by th[illegible] of the sun.

Now man is copying nature. Nobel [illegible] ate Melvin Calvin, a chemist at the Univ[illegible] of California at Berkeley, has produced [illegible] thetic chloroplasts. Natural chlorop[illegible] found in the cells of green plants, are [illegible] shaped structures that manufacture the [illegible] carbohydrates needed to sustain nearly [illegible] creature on earth. They produce this [illegible] photosynthesis, a chemical process invol[illegible] sunlight, water, and carbon dioxide. [illegible] sense, sunlight striking a chloroplast [illegible] hydrogen from water, allowing the hydro[illegible] to combine with carbon dioxide from the a[illegible] form the carbohydrates needed for the pla[illegible] growth. The oxygen released from the [illegible] water molecules drifts away to become par[illegible] the atmosphere.

Calvin's artificial chloroplasts—[illegible] spheres of oil floating in water in his Ber[illegible] ley laboratory—are different from the [illegible] thing in one essential way: they are [illegible] signed to help hydrogen combine with [illegible] bon dioxide to form new plant material. [illegible] stead, as the diagram on the opposite pa[illegible] shows, they release hydrogen in the form [illegible] a gas.

When Calvin completed mapping the pa[illegible] synthesis of carbohydrates, the feat for which he won his Nobel in 1961, some sci[illegible] entists believed that the day was not far off when ample quantities of hydrogen could be produced economically. Achieving that goal, however, turned out to be extraordinarily dif[illegible] ficult. It required learning about the hundreds of chemical reactions that take place during the first phase of photosynthesis. Calvin and others have spent the past 20 years trying to decipher those reactions.

What they finally unraveled was a [illegible] dously complex process. The membrane[illegible] surrounding a natural chloroplast are [illegible] inside and out, with molecules of chlorophy[illegible] the green pigment that gives a plant its co[illegible] or. Whenever a photon, a unit of light, strike[illegible] a chloroplast, energy is transferred to an ele[illegible] tron in a chlorophyll molecule. The energize[illegible] electron leaps from the molecule, leaving [illegible] with a "hole" that would ordinarily pull th[illegible] electron back. But the electron pass[illegible] through the chloroplast membrane, whic[illegible] traps it and allows it to be captured by a [illegible] and makes leaf chlorophyll located inside the [illegible] membrane.

At this point water, brought up throug[illegible] the roots and present in the plant tissue, [illegible]

(A5.)