the actual combination of various percentages of alcohol with gasoline for use as fuel in European countries in the early 1930's.

However, use of a fuel composed of a mixture of water-miscible alcohols and gasoline has some drawbacks. If alcohols were added in percentages that would make their blending with gasoline practical, the absorption of moisture by the blend would not only affect the octane number of the mixed fuel, but would have a corrosive effect on the pistons and cylinder walls of modern automobile engines, particularly under the high heat of compression prevalent in such engines.

On the other hand, *n*-butyl alcohol and other higher carbon alcohols that are immiscible with water would be too expensive to use for blending unless new methods of fermentation could be applied to the large-scale manufacture of these alcohols.

Another problem would be the raising of the flash point of the vapor of the mixtures; this would tend to adversely affect the propulsive properties of the exploding gases in the engines. New engines might have to be designed to cope with the changes resulting from the use of blended fuels.

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In response to Castor's letter regarding the possibility of a "cheap, rapid method of hydrolyzing cellulose," we offer the following information.

Any number of methods have been proposed for *direct* or *indirect* utilization of cellulose wastes to produce food, energy, or chemical feedstocks. An indirect method, enzymatic conversion, using the cellulase complex of enzymes to hydrolyze cellulose to soluble sugars has been pioneered at Natick Laboratories (*1*). Glucose produced from waste cellulose can be used to grow yeast, or other single cell protein, to produce fuels, solvents, chemicals, antibiotics, and enzymes by microbial conversion and chemicals and raw materials by chemical conversion. Enzymatic hydrolysis, unlike acid hydrolysis, is selective. Only the cellulose is solubilized, and the crude sugar syrups produced are reasonably free of extraneous substances, reversion compounds, and so forth, and reasonably constant in composition when derived from various sources of waste.

The process as presently conceived consists of three operations. The enzyme is produced in a submerged fermentation with the crude culture filtrate being used as the enzyme solution. Waste cellulose is shredded and milled and, in the third operation, is mixed with the culture filtrate in an enzyme reactor. The cellulose remains as a solid substrate and glucose syrups are withdrawn through a filter. Mutants of the fungus *Trichoderma viride* are used in the fermentation process to produce large quantities of the cellulase enzyme. These strains have been freely distributed to other investigators and are now being used in several other laboratories for saccharification studies.

We hope through continued effort to further develop this cheap rapid method of hydrolyzing cellulose so that some day many of the ideas put forth by Castor will become reality.

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The Dirigible

In the search for long-term energy, pollution, and transportation solutions, the dirigible, revived and modernized, deserves consideration. The advantages of a large buoyant aircraft are many. Being lighter than air, it is borne aloft by the lifting surge of its helium, using propulsive power only to move and maneuver. The airship's energy needs are accordingly low, so low that it lends itself more immediately and practicably to nuclear propulsion than does any other type of aircraft.

The large airship is environmentally attractive: it employs "clean" propulsion techniques. It can also be exceptionally quiet. To take off, it floats skyward. To land, it settles to the ground. Runways are not needed. Only a flat clearing which—ecologists please note—can be an open field. In some cases, using thrust vector control, the craft should be able to hover and winch shipments up and down without landing, an ability with immense implications for the future of air cargo transportation.

A commercial version with a volume of 750,000 cubic meters (four times the volume of the *Hindenburg*) could fly a payload of 270,000 kilograms nonstop at 160 to 200 kilometers per hour between North and South America. Southbound, it might carry automobiles on transporter racks beneath the hull from assembly plants to foreign points. Returning, it could penetrate undeveloped Latin American interiors to airlift out agricultural products, timber, or other resources.

Stable and vibration-free, the dirigible could perform uniquely and usefully as an airborne scientific work platform, its size enabling antennas, data processing facilities, and other equipment to be carried with few constraints imposed by weight or geometry. As a flying oceanographic research ship, it could markedly reduce transit times, overfly and reach ice-blocked regions, and serve as a long-range and long-endurance "mother" to aircraft, environmental buoys, sensor-equipped RPV's (remotely piloted vehicles), survey launches, and research submersibles, all of which it could carry, launch, and recover, employing techniques developed by airships in the 1920's and 1930's.

Modern technology has not been applied to the development of a rigid airship, the type best suited to achieve the performance potential of large dirigibles, for about 35 years. By using materials and engineering techniques as sophisticated as those that went into Saturn 5, Skylab, and the jumbo jets, we should be able to make airships safe and practical. But a survey of aerospace firms has shown that few are inclined to pursue the dirigible concept in any way, a preference to adhere to established product lines being the reason usually given.

The dirigible has much to offer. Since the aerospace firms are apparently not interested, is there some other segment of the American scientific and technological community, not so committed to existing programs, that is willing to take up the challenge?

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