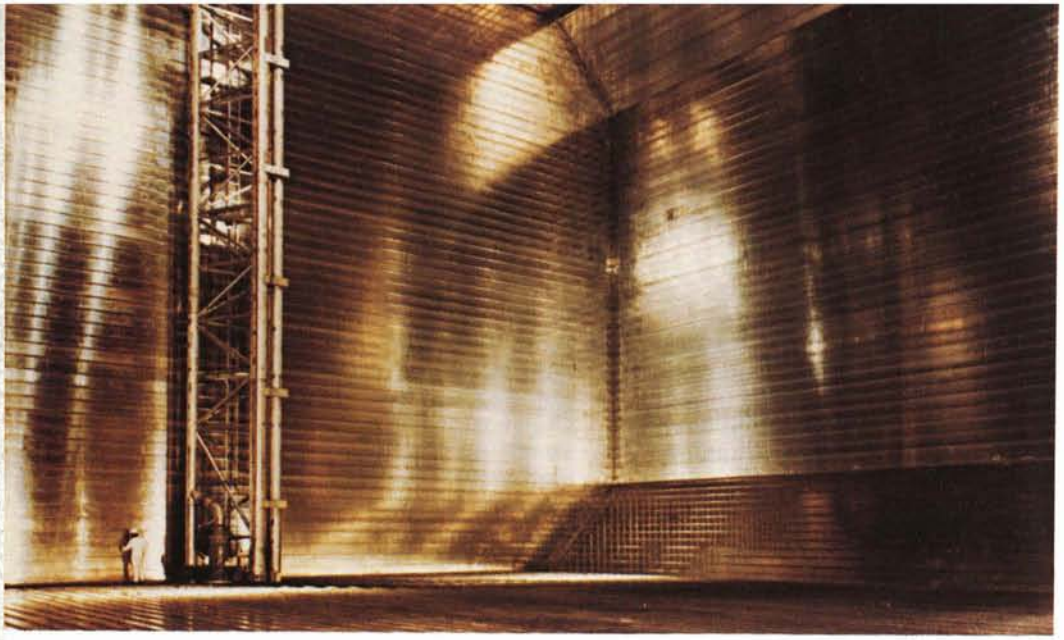

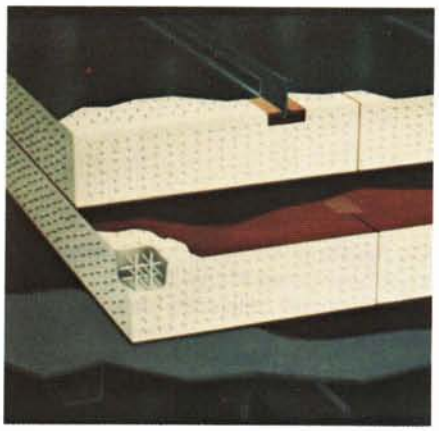

layers of a new type of 3D designed specifically for the special needs of LNG containment. Above is a cutaway of the combined Invar-3D system. The top layer of Invar is the primary barrier, in physical contact with the LNG. The secondary barrier, shown in white, consists of two four-inch layers of 3D separated by a fiberglass liner. The Gaz-Transport/McDonnell Douglas system offers reduced boiloff, high strength, low cost and long durability.

First use of Invar-3D will be aboard two LNG ships now under construction; the cutaway view in the bottom photo shows one of the insulated tanks at midship. These ships are being built by the Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania, for Western LNG Terminal Associates, a subsidiary of Pacific Lighting Corporation, Los Angeles, California. Beginning in 1982, they will carry LNG from Alaska to California, where the fuel will be converted to gaseous state for distribution to consumers by Southern California Gas Company, Pacific Lighting's utility subsidiary, and by Pacific Gas and Electric Company, San Francisco, California.

Tank Insulation

For NASA's Apollo program, McDonnell Douglas Astronautics Company, Huntington Beach, California, developed and built the S-IVB, uppermost stage of the three-stage Saturn V moonbooster. An important part of the development task was fabrication of a tank to contain liquid hydrogen fuel for the stage's rocket engine. The liquid hydrogen had to be contained at the supercold temperature of 423 degrees below zero Fahrenheit. The tank had to be perfectly insulated to keep engine or solar heat from reaching the fuel; if the hydrogen were permitted to warm up, it would have boiled off, or converted to gaseous form, reducing the amount of fuel available to the engine.

McDonnell Douglas' answer was a supereffective insulation called 3D, which consisted of a one-inch thickness of polyurethane foam reinforced in three dimensions with fiberglass threads. Over a 13-year development and construction period, the company built 30 tanks and never experienced a failure. Now, after years of additional development, an advanced version of 3D is finding application as part of a containment system for transporting Liquefied Natural Gas (LNG) by ship.

For ship movement, converting gas to liquid form reduces its volume by more than 600 times, making it an easily manageable and economically attractive cargo. LNG is reconverted to gaseous state after it reaches destination. Like space-used liquid hydrogen, LNG must be contained at very low temperatures—about 260 degrees below zero Fahrenheit—to prevent loss by boiloff.

McDonnell Douglas Astronautics has teamed with a French firm—Gaz-Transport S.A.R.L. of Paris—in development of an advanced technology liquefied gas containment system for LNG carrier ships. Gaz-Transport had earlier developed a metal insulating membrane called Invar, which has already logged several million safe sea miles aboard LNG ships; the upper left photo shows the interior of an Invar-insulated shipboard tank. The new jointly developed system couples an outer layer of Invar with inner