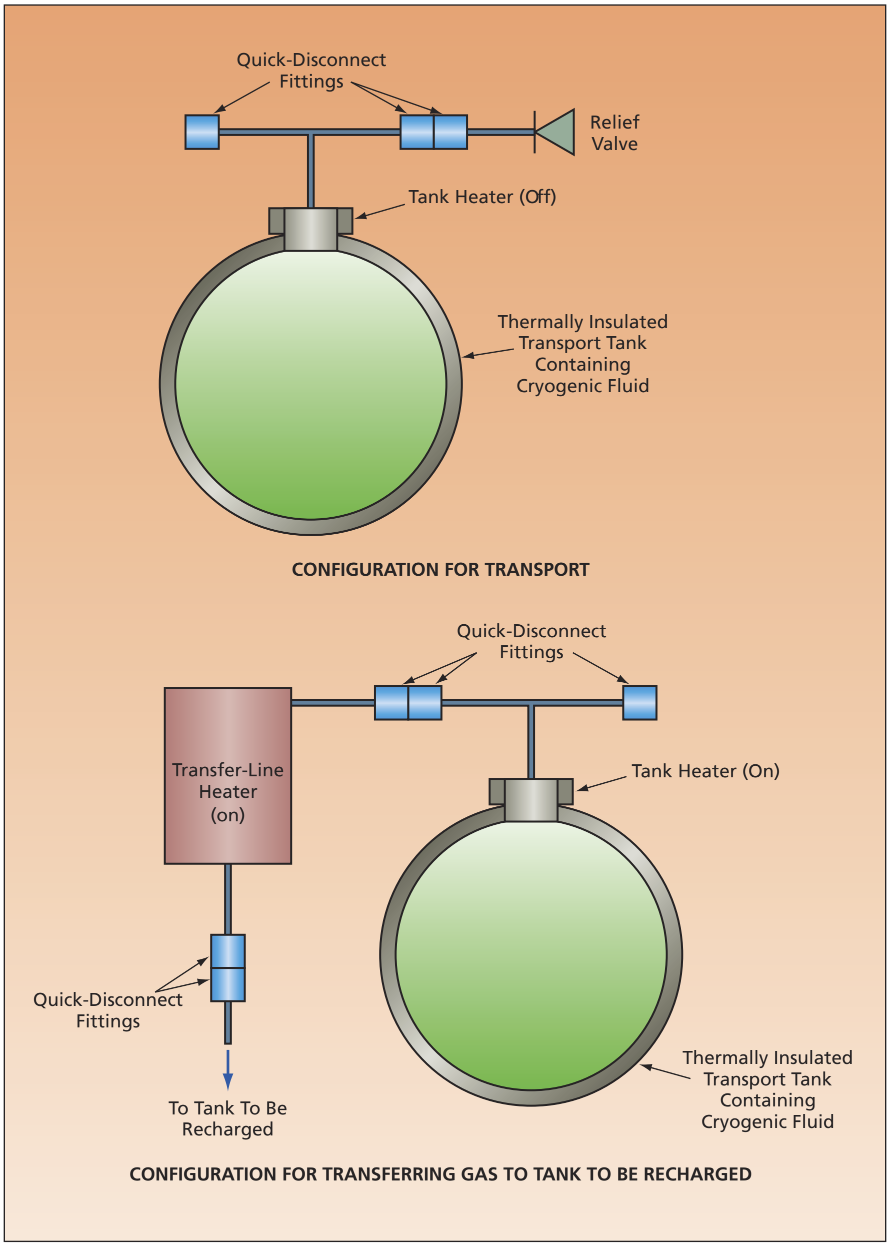
Physical Sciences

Cryogenic Transport of High-Pressure-System Recharge Gas

Advantages include low pressure and high density during transport.

Lyndon B. Johnson Space Center, Houston, Texas

A method of relatively safe, compact, efficient recharging of a high-pressure room-temperature gas supply has been proposed. In this method, the gas would be liquefied at the source for transport as a cryogenic fluid at or slightly above atmospheric pressure. Upon reaching the destination, a simple heating/expansion process would be used to (1) convert the transported cryogenic fluid to the room-temperature, high-pressure gaseous form in which it is intended to be utilized and (2) transfer the resulting gas to the storage tank of the system to be recharged.



An **Insulated Transport Tank** would contain a cryogenic fluid, which would be warmed to convert it to a pressurized gas.

In conventional practice for recharging high-pressure-gas systems, gases are transported at room temperature in high-pressure tanks. For recharging a given system to a specified pressure, a transport tank must contain the recharge gas at a much higher pressure. At the destination, the transport tank is connected to the system storage tank to be recharged, and the pressures in the transport tank and the system storage tank are allowed to equalize. One major disadvantage of the conventional approach is that the high transport pressure poses a hazard. Another disadvantage is the waste of a significant amount of recharge gas. Because the transport tank is disconnected from the system storage tank when it is at the specified system recharge pressure, the transport tank still contains a significant amount of recharge gas (typically on the order of half of the amount transported) that cannot be used.

In the proposed method, the cryogenic fluid would be transported in a suitably thermally insulated tank that would be capable of withstanding the recharge pressure of the destination tank. The tank would be equipped with quick-disconnect fluid-transfer fittings and with a low-power electric heater (which would not be used during transport). In preparation for transport, a relief valve would be attached via one of the quick-disconnect fittings (see figure). During transport, the interior of the tank would be kept at a near-ambient pressure — far below the recharge pressure. As leakage of heat into the tank caused vaporization of the cryogenic fluid, the resulting gas would be vented through the relief valve, which would be set to maintain the pressure in the tank at the transport value. Inasmuch as the density of a cryogenic fluid at atmospheric pressure greatly exceeds that of the corresponding gas in a practical high-pressure tank at room temperature, a tank for transporting a given mass of gas according to the proposed method could be smaller (and, hence, less massive) than is a tank needed for transporting the same mass of gas according to the conventional method.

Upon arrival at the destination, the transport tank would be connected to the tank to be recharged via a transfer line that would include a second low-power electric heater. The relief valve would be disconnected and the line to the gas system opened, causing the pressure in the transport tank to rise to the system pressure. The transport tank and transfer-line electric heaters would be turned on, causing the contents of the tank to expand under high pressure and flow out through the transfer line. The transfer-line heater would further warm the flowing fluid to room temperature. The relative power levels of the electric heaters would be set to ensure that the fluid expelled from the tank by the tank heater could be delivered as room-temperature gas to the tank to be recharged. The transfer of gas would be complete once the remaining gas inside the transport tank had been heated to room temperature. By virtue of the difference between densities, at completion, the majority of the mass of the transported cryogenic fluid would have been converted to gas and transferred to the recharged tank.

This work was done by Eugene K. Ungar and Warren P. Ruemmele of Johnson Space Center and William Carl Bohannon of The Boeing Co. Further information is contained in a TSP (see page 1). MSC-24343-1

Water-Vapor Raman Lidar System Reaches Higher Altitude

Signal-to-noise ratios are increased over those of prior such systems.

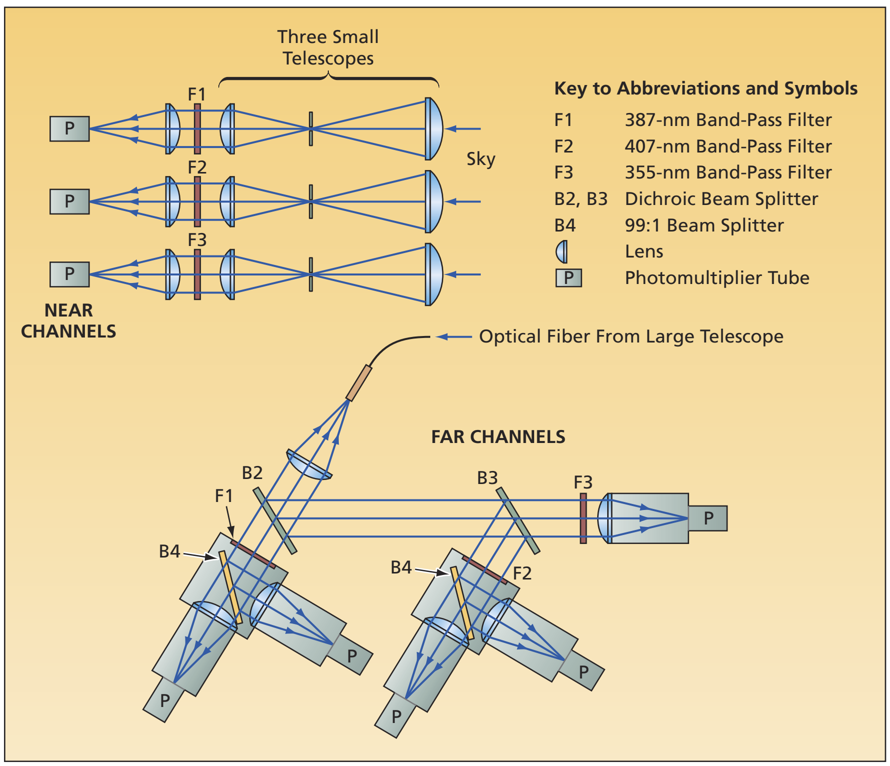
NASA's Jet Propulsion Laboratory, Pasadena, California

A Raman lidar system for measuring the vertical distribution of water vapor in the atmosphere is located at the Table Mountain Facility (TMF) in California. Raman lidar systems for obtaining vertical water-vapor profiles in the troposphere have been in use for some time. The TMF system incorporates a number of improvements over prior such systems that enable extension of the altitude range of measurements through the tropopause into the lower stratosphere.

One major obstacle to extension of the altitude range is the fact that the mixing ratio of water vapor in the tropopause and the lower stratosphere is so low that Raman lidar measurements in this region are limited by noise. Therefore, the design of the TMF system incorporates several features intended to maximize the signal-to-noise ratio. These features include (1) the use of 355-nm-wavelength laser pulses having an energy (0.9 J per pulse) that is high relative to the laser-pulse energy levels of prior such systems, (2) a telescope having a large aperture (91 cm in diameter) and a narrow field of view (angular width ≈0.6 mrad), and (3) narrow-bandpass (wavelength bandwidth 0.6 nm) filters for the water-vapor Raman spectral channels. In addition to the large-aperture telescope, three telescopes having apertures 7.5 cm in diameter are used to collect returns from low altitudes.

The receiver portion of this lidar system has a total of eight channels (see figure). These include three channels for the water-vapor Raman returns at a wavelength of 407 nm, three channels for the nitrogen Raman returns at a wavelength of 387 nm, and two channels for elastic-scattering returns at the laser wavelength of 355 nm. Three of the channels (a 387-, a 407-, and a 355-nm channel), denoted the near channels, process the Raman and elastic returns collected by the three smaller telescopes. The remaining five channels, denoted the far channels, process the Raman and elastic returns collected by the large telescope. The elastic-scattering returns are used primarily for deriving temperature profiles. The light in each channel is measured by use of a photomultiplier tube, the output of which is fed to a commercially available optical-transient recorder operating as a photon-counting multichannel scaler. The altitude interval of each bin of the scaler is 7.5 m, but typically, bins are summed together in groups of 10, yielding discretization of altitude in increments of 75 m.

The light collected by the large telescope is focused into an optical fiber, which delivers the light to a lens that



These Partly Schematic Optical Layouts show the paths followed by Raman and elastically scattered returns collected by a large telescope and three smaller telescopes.