

# LNG Technology Trends

## Part two of our round-up of NGV-related patents

by Wolf H. Koch, Ph.D

In providing technology updates about service station equipment, my company has collected information on many alternative fuels patents. I reported on compressed natural gas (CNG) technology trends in the May issue of NATURAL GAS FUELS This article covers liquefied natural gas

(LNG)-related patents for 1995 and 1996. While our patent search includes European and World patents, we found only one World LNG patent with potential ramifications in the vehicle market. As expected, the majority of the reviewed patents cover various aspects of dispensing. Of a total of

18 patents, 15 fall into that category: eight cover LNG dispensing or converting LNG to CNG; three describe an LNG pump system; two, a portable LNG fueling facility; and the last two, safety devices. The last three non-dispensing patents treat various uses of LNG in large engines and turbines. The table below lists the 1995 and 1996 LNG patents that we collected.

**Table 1**  
**1995-1996 LNG Patents**

Type	Patent No.	Inventor/Assignee	Patent Title
US	5 400 588	Masami Yamane Kabushiki Kaisha Kobe Seiko Sho	Mechanism for firing gas turbine engines with LNG
US	5 409 046	Paul F. Swenson Unassigned	System for fast-filling compressed natural gas powered vehicle
US	5 411 374	Anker Gram Process Systems Int'l.	Cryogenic fluid pump system and method of pumping cryogenic fluid
US	5 421 160	Keith Gustafson Minnesota Valley Engineering, Inc.	No loss fueling system for natural gas powered vehicles
US	5 421 161	Keith Gustafson Minnesota Valley Engineering, Inc.	Storage system for cryogenic fluids
US	5 421 162	Keith Gustafson; Minnesota Valley Engineering, Inc.	LNG delivery system
US	5 441 234	George White Unassigned	Fuel systems
US	5 457 951	Paul Johnson Cabot Corporation	Improved LNG fueled combined cycle power plant
US	5 465 583	John Goode Hydra Rig, Inc.	Liquid methane fueling facility
US	5 477 690	Anker Gram Process Systems Int'l.	Liquid cryogenic storage tank system
US	5 505 232	John A. Barclay CryoFuel Systems, Inc.	Integrated refueling system for vehicles
US	5 537 824	Keith Gustafson Minnesota Valley Engineering, Inc.	No loss fueling system for natural gas powered vehicles
US	5 544 685	Dale Stieferman Keifer Controls, Inc.	Fill controller for liquefied gas container and apparatus for filling tank
US	5 551 488	Anker Gram Process Systems Int'l.	Method of filling a two compartment storage tank with cryogenic liquid
US	5 566 712	George White Unassigned	Fueling system for cryogenic liquid
US	5 572 875	Keith Gustafson Minnesota Valley Engineering, Inc.	Relief valve construction to minimize ignition hazard from cryogenic storage tanks containing volatile liquids
US	5 582 218	Jeffrey Beale; Unassigned	Dispensing system for refueling transport containers with cryogenic liquids
US WO	5 586 050 9 605 561	Darby Makel Aerojet General Corp.	Remotely controllable LNG field station management system.

### Dispensing and Pumping

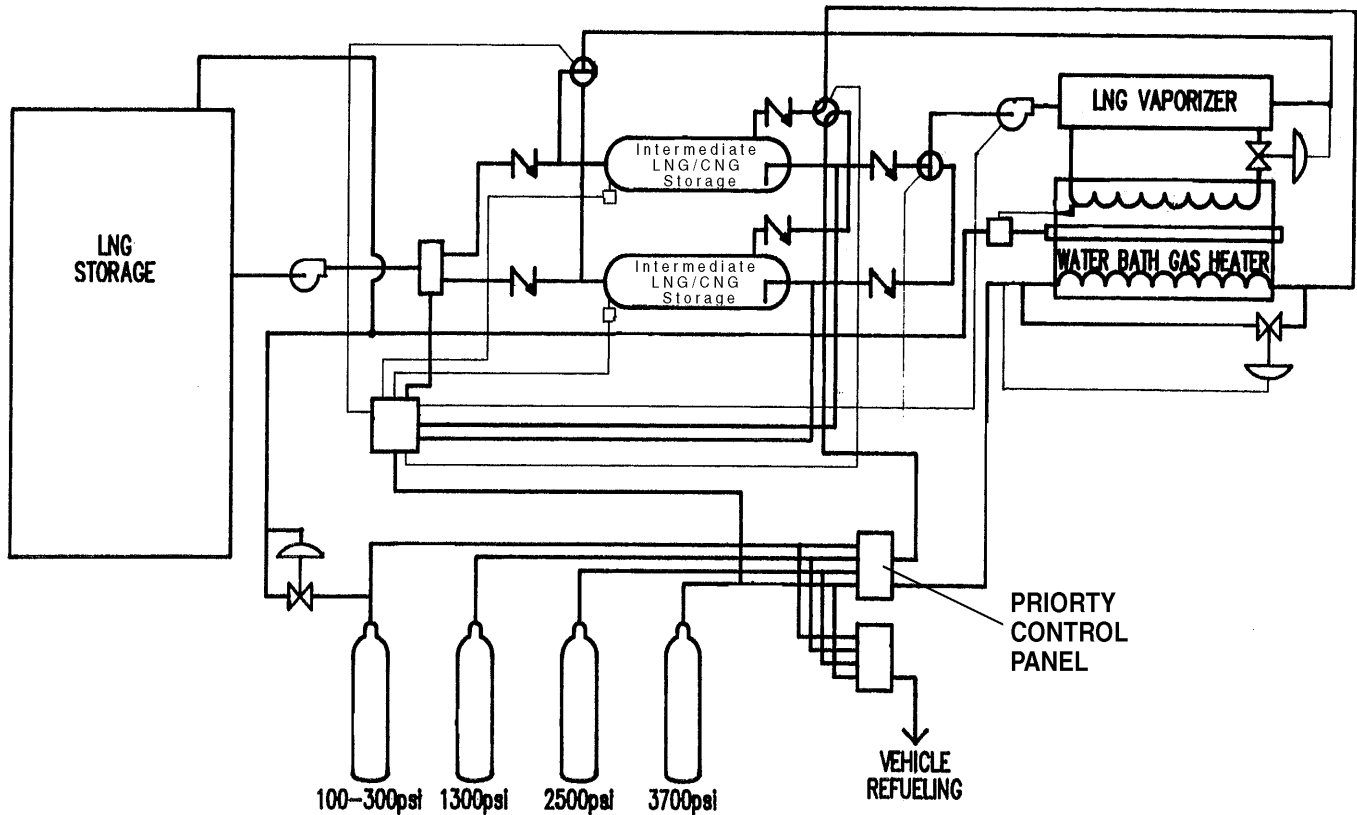
Minnesota Valley Engineering (MVE) received four patents for dispensing systems and one for safety devices. Two patents describe no-loss LNG fueling (US 5,421,160 and 5,537,824) by returning the vented gas from the vehicle tank back to the fueling station. US 5,421,161 highlights a cryogenic storage system, while US 5,421,162 describes a LNG delivery system for CNG saturated LNG. Together with a patent on the design of a relief valve and restrictor orifice (US 5,572,875), MVE covers most aspects of LNG dispensing in its five patents.

Two additional patents cover LNG dispensing systems: US 5,465,583 and 5,582,218. The former is designed for ease-of-use by untrained operators, while the latter features the controlled removal of vapor and delivery of LNG through a single line.

The last two dispensing patents, US 5,505,232 and 5,409,046, include systems for converting LNG to CNG and dispensing high-pressure CNG. The first includes an air-heated heat exchanger, fueled with natural gas. The second vaporizes LNG through heat exchange with the incoming natural gas.

A typical system for vaporizing LNG to high-pressure CNG is

Figure 1 US 5,409,046



shown in **Figure 1**. Intermediate storage tanks are alternately filled with LNG which is vaporized in the heater and maintained at 3,700 psi. The CNG is provided to a storage cascade through the priority panel valve. The process provides CNG from LNG without a compressor section.

Process Systems International received three patents (US 5,411,374; 5,477,690 and 5,551,488) on the design and use of a cryogenic pump. The pump does not need to be inside the cryogenic container and features steady-state flow with negligible vaporization through heat absorption.

### Portable Stations

Two patents, US 5,586,050 and WO 96 05561, were awarded to Aerojet General Corp. for the design of a portable LNG fueling facility. In many ways, the station is similar in concept to portable gasoline stations designed by Elf in France and those found in many Eastern European countries: they generally are designed to fit into standard-size

containers for portability and include all equipment for operating the site. These patents include a secure communications link for sales authorization through an automated point-of-sales system, as well as the tankage, dispensing equipment and safety devices for leak detection and inventory control and reconciliation. While this invention does not claim to invent portable LNG station designs, its value lies primarily in the unattended, secure sales authorization with credit, access or proximity cards. The main use for this facility may be construction or other remote sites for fleet locations. **Figures 2 and 3** show the station point-of-sales panel and equipment layout.

### Safety and Utilization

Two patents address safety issues with regard to LNG dispensing. MVE designed a second relief valve and restrictor orifice downstream of the primary relief valve (US 5,572,875). When the relief valves open, the orifice produces a high gas velocity, thus minimizing igni-

tion hazards. Keifer Controls has developed a sensor float for monitoring fill levels in LNG tanks and provide for a safe shut-off (US 5,544,685).

While the great majority of patents cover the dispensing process, three cover LNG utilization in large engines. US 5,441,234 and 5,566,712 claim the use of cryogenic fuel injectors for injecting LNG directly into the combustion chambers of diesel or spark ignition engines. The invention references use of the system in railroads, where a large LNG tank may be carried on-board. A method for vaporizing LNG and firing it in a gas turbine is disclosed in US 5,400,588. An alternative design for gasification and expansion is shown in US 5,457,951.

### Outlook

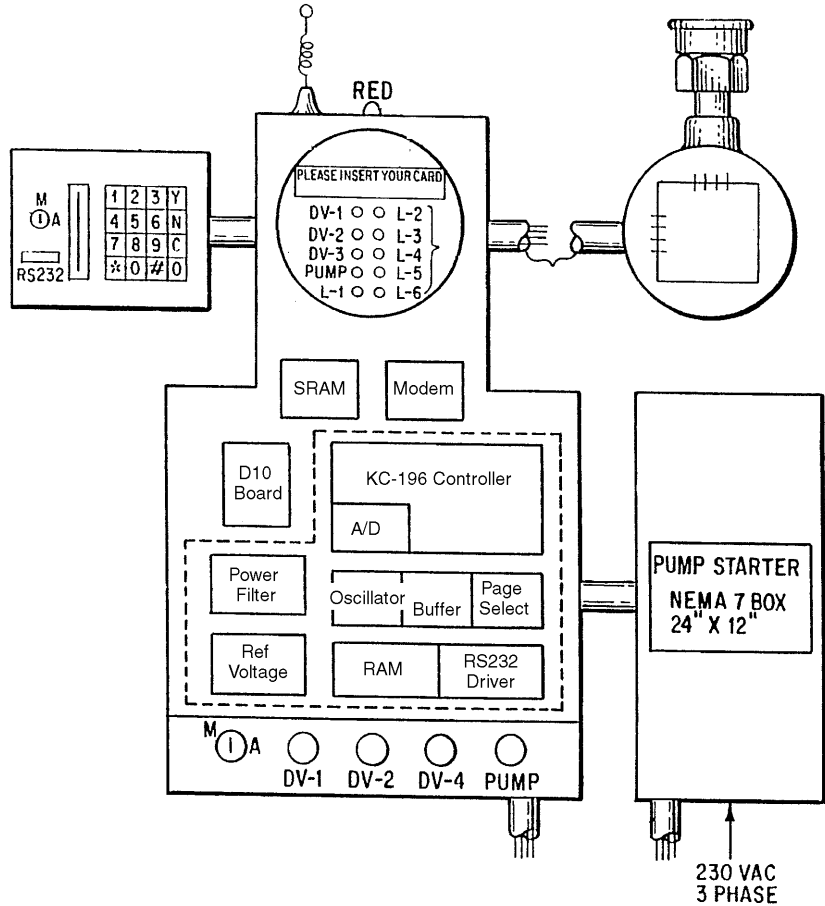
Patents issued in 1995 and 1996 cover very broad areas of LNG utilization. There are a number of additional patents describing various aspects of LNG manufacturing which are not covered by this

review. At this time, technology employing LNG as fuel is primarily found in industrial and fleet applications. It is interesting to note that two patents for portable LNG dispensing facility have future retail applications. Also just two patents describe processes for converting LNG to CNG, designs that have obvious potential in both retail and fleet markets.

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This reprint represents the uncut version of the published article and includes an additional page and two drawings.

**Figure 2 US 5,586,050**



**Figure 3 US 5,586,050**

