



FROM the FIELD

Part One: CNG

Inventions Power the Engine of Progress

Patents provide a glimpse of promising new NGV technology

by Wolf H. Koch, Ph.D

For some time now, our firm has provided technology awareness and update services for clients in the retail service station sector. In the process, we have gathered information about many alternative fuels patents that collectively provide insight into technology trends in the natural gas vehicle industry.

This article, the first of two parts, features patents issued in 1995 and 1996 for compressed natural gas (CNG) technology related particularly to vehicle fueling applications. Patents for LNG technology will be featured in Part Two, which will be published in an upcoming issue of NATURAL GAS FUELS.

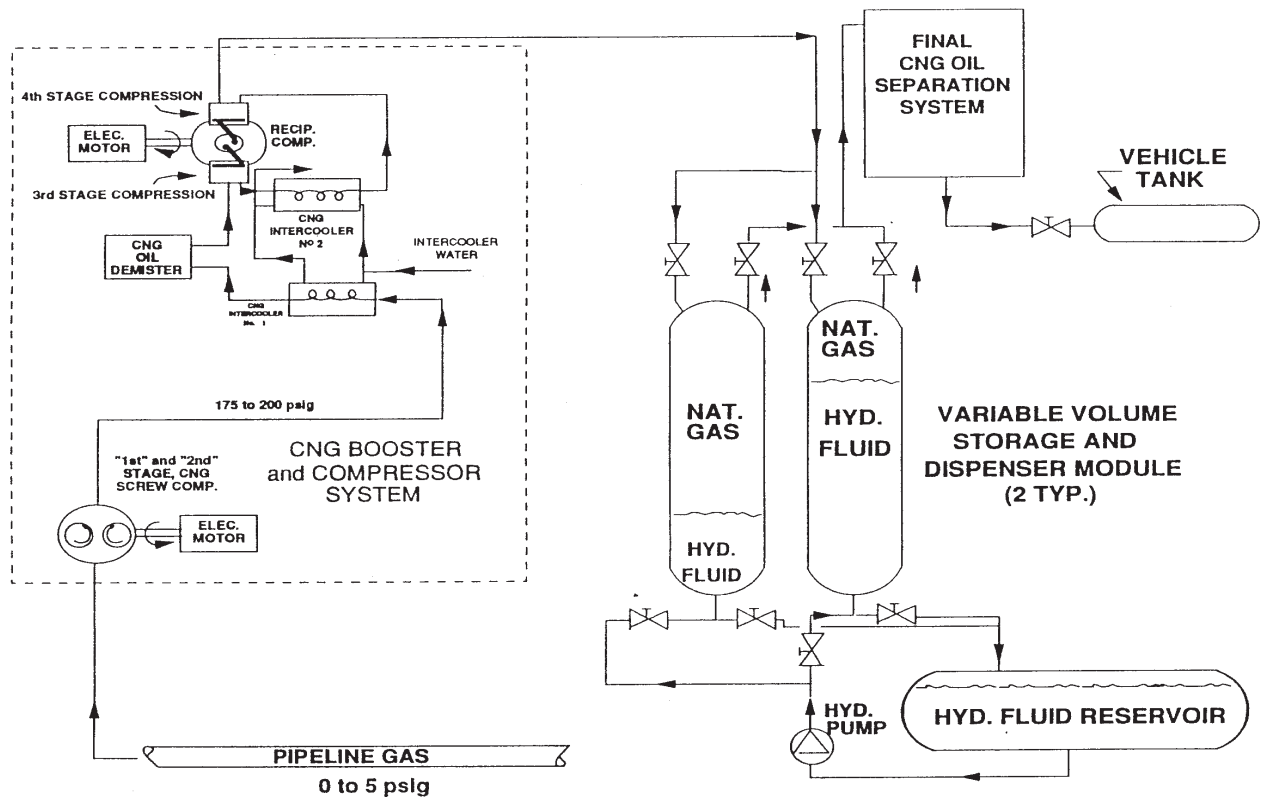
Our patent searches cover U.S., European and World (PCT) patent databases. Because of patent availability and language difficulties, we do not search for individual country patents. A number of applicable European and World patents are published in French and German.

Readers unfamiliar with European and World patents may be interested to learn that these patents generally constitute publication. Objections to the issuance of final patents may be filed within specified time periods. These patents also tend to issue six to 12 months prior to their U.S. counterparts in cases where inventors file concurrent applications.

1995-1996 CNG Patents

| Type | Patent No. | Inventor/Assignee | Patent Title |
|------|------------|--|--|
| US | 5 377 646 | Ronald Chasteen; Pacer Industries, Inc. | LPG and CNG engine fuel delivery systems |
| US | 5 385 176 | Billy F. Price | Natural gas dispensing with multiple compressors |
| WO | 9 503 218 | Price Compressor Co. | |
| US | 5 387 089 | John Stogner, et. al.; Tren Fuels, Inc. | Method and apparatus for compressing gases with a liquid system |
| US | 5 406 988 | Pat F. Hopkins; Pacific Cryogenics, Inc. | Method and apparatus for dispensing compressed gas into a vehicle |
| US | 5 410 908 | Herman Erichsen; Data Instruments Inc. | Measuring the quantity of a gas in a tank |
| US | 5 452 738 | Robin Borland, et. al.; Amcast Industrial Corp. | Crashworthy solenoid actuated valve for CNG powered vehicles |
| US | 5 454 408 | Francis A. DiBella, et. al.; Thermo Power Corp. | Variable-volume storage and dispensing apparatus for CNG |
| US | 5 458 258 | Jerry White, et. al.; Dow Chemical Co. | Storage tanks for compressed natural gas with a hydroxy-phenoxyether polymer barrier liner |
| US | 5 479 966 | Raymond Tison, et. al.; Consolidated Natural Gas Service Company | Quick fill fuel charge process |
| US | 5 531 199 | Peter Bryant, et. al.; United Fuels Limited | Internal combustion engines operating with pressurized gas as fuel |
| US | 5 538 051 | Jack Brown, et. al.; Pinnacle CNG Systems, L.L.C. | CNG refueling system for multiple vehicles |
| US | 5 542 459 | Billy Price, et. al.; Price Compressor Co. | Process and apparatus for complete fast filling with dehydrated CNG |
| US | 5 551 490 | Kenneth Kountz, et. al.; Gas Research Institute | Apparatus and method for controlling the charging of NGV cylinders from natural gas refueling stations |
| US | 5 562 117 | Robin Borland, et. al.; Amcast Industrial Corp. | Crashworthy solenoid actuated valve for CNG powered vehicle |
| US | 5 564 306 | Charles Miller | Density compensated CNG flow meter |
| WO | 9 532 405 | Marcum Fuel Systems, Inc. | |
| US | 5 570 729 | Heinz Mutter; Sulzer-Burckhardt AG | Method and apparatus for the rapid filling of a pressure container with a gaseous medium |
| US | 5 577 630 | Michael Blair, et. al.; Thiokol Corporation | Composite conformable pressure vessel |
| WO | 9 622 915 | David Diggins; Pinnacle CNG Systems, L.L.C. | System and method for dispensing pressurized gas |

Figure 1



The table lists 20 patents issued during 1995-1996 on CNG-related topics. Fourteen patents cover various aspects of CNG dispensing, while six relate to vehicle operations and equipment.

CNG Dispensing

As one might expect, by far the largest share of CNG patents relates to the dispensing process. A number of organizations have established a proprietary niche in protecting their approach to overcoming problems associated with temperature-compensated quick-fill CNG fueling systems. Others describe multi-compressor systems in order to increase the cost-effectiveness of compressor cycling.

Two patents by Stogner (US 5,387,089) and DiBella (US 5,454,408) describe hydraulic compression systems. The first uses only hydraulic ramps, while the second uses a direct-fill compressor augmented by cylinders containing hydraulic fluid or hydraulically driven pistons. This patent also covers an integrated system with a variable-volume vehicle tank. The DiBella patent is the result of studies by Brooklyn Union Gas¹ and is shown in Figure 1.

The concept was taken a step further by W. Ticac, who proposed a mother-daughter system of CNG trailers operating with hydraulic ramps.² The Gas Research Institute investigated a similar concept, using a booster pump to increase trailer utilization, rather than the hydraulic systems proposed³ in the patents.

Three methods of temperature-compensated quick-fills are described separately by Tison (US 5,479,966), Kountz (US 5,551,490) and Mutter (US 5,570,729). Another, Diggins (WO 96/22915), takes the concept a step further by instrumenting the vehicle tank for temperature, pressure and water volume, then connecting it to the onboard vehicle computer, which in turn is connected to the dispensing system computer via hard-wired or radio frequency connection. Figure 2 describes the information flow for Diggins' invention.

Optimization of the compression process is the subject of five patents. Price (US 5,385,176; WO 95/03218; and US 5,542,459) describes compressor systems that employ additional compression stages or an additional single-stage compressor for topping off the storage cascade. He also integrates dehydration and gas cooling into the compressor train in order to deliver a maximum fill to the vehicle tank. Hopkins (US 5,406,988) uses multi-stage storage and a booster compressor for optimization.

Finally, Brown (US 5,538,051) maximizes compressor performance by optimizing suction pressure through a system of intermediate storage.

Three additional patents describe metering and measuring technology. Erichsen (US 5,410,908) protected a sensing circuit for measuring the amount of gas in a tank. Miller (US 5,564,306 and WO 95/32405) describes a density compensated mass flow meter that determines mass flows as a function of specific heat ratio.

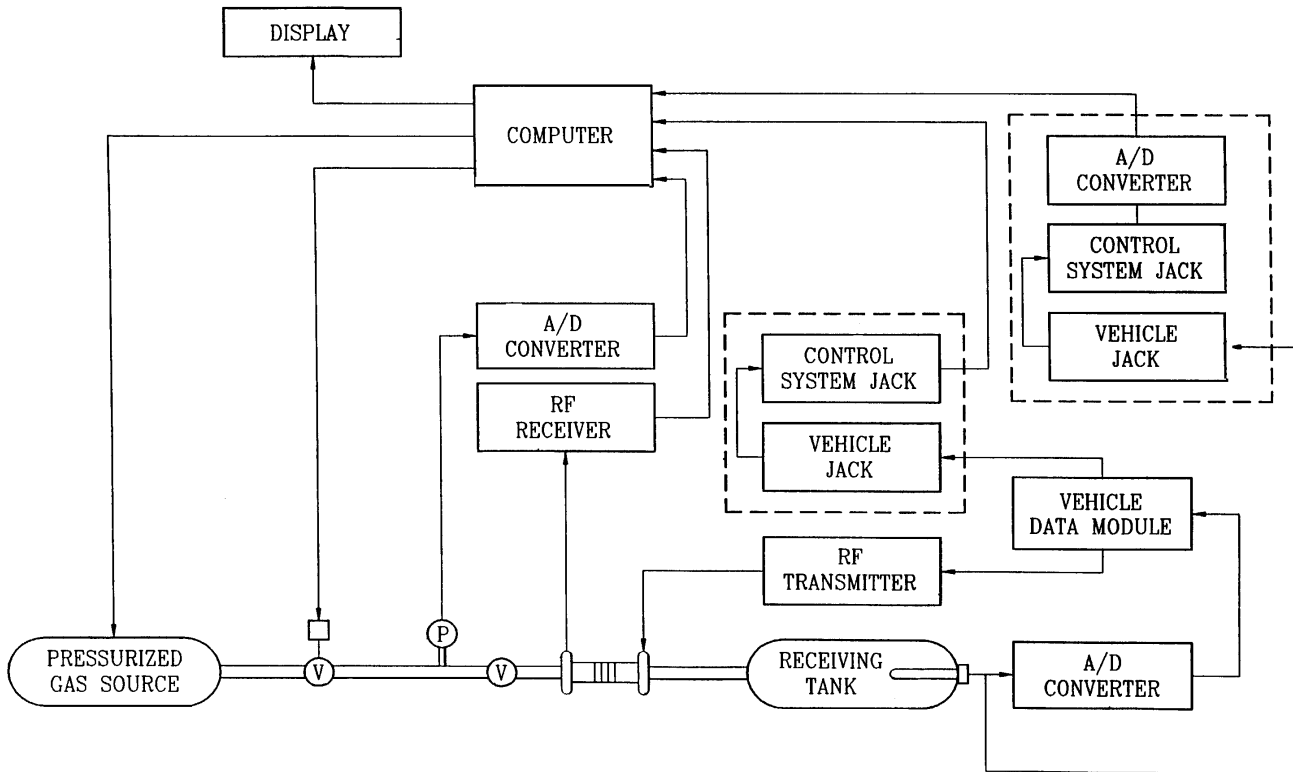
Vehicle Systems

Vehicle system patents for 1995 and 1996 cover engine operation, safety and tanks. Chasteen (US 5,377,646) and Bryant (US 5,531,199) cover vehicle fuel systems and engine operations with fuels supplied under high pressure.

Borland (US 5,452,738 and 5,562,117) invented a vehicle tank solenoid valve that shuts off fuel supply in the event of a catastrophic failure, such as in a crash. White (US 5,458,258) developed a polymer barrier lining for CNG tanks.

Composite conformable vehicle tanks are the subject of a patent by Blair (US 5,577,630), who has maximized available space utilization by using non-circular cylinders for vehicle tank systems, as shown in Figure 3.

Figure 2



Technology Trends

While most patents are devoted to CNG dispensing, it is interesting to note that only a handful protect individual equipment items. The great majority of CNG patents issued in the 1995-1996 period deal with optimization issues designed to decrease compression costs and increase fueling efficiency. These are the marks of a maturing industry.

It is also interesting to note that only two of the twenty patents addressed here belong to companies or individuals outside the United States. With previous and current CNG activities in Canada and Europe, it is surprising that manufacturers in those regions are not protecting their know-how by securing U.S. patents.

Wolf Koch is founder and president of Technology Resources International in Batavia, Ill. He provides consulting in technology planning and evaluation, product development and testing and litigation support. His experience includes 20 years of managing engineering projects for a major oil company, including retail service station, product distribution and alternative fuels technologies. He has been a professor of chemical engineering and is currently contributing technology editor for Petroleum Equipment & Technology.

Footnotes

1. F.A. DiBella, "Variable Volume Advanced CNG Refueling Systems," presented at the Brooklyn Union Gas 1995 Research, Development and Demonstration Fair.
2. W. Ticac, "A Different Approach to CNG Refueling," presented at the American Energy Week '95 Conference, Jan. 31 - Feb. 2, 1995.
3. J. Keder and K. Darrow, "NGV Stations Based on Mobile Tube Trailer: An Economic Analysis," GRI Report GRI-95/0021, January 1995.

Figure 3

