Repairing And Preserving A Classic Corvette 'Fuelie'

Text by Steve Temple, photos by the author and Jim Lockwood

It's been more than five decades since the first mechanical fuel injection system was introduced on the C1 Corvette and full-size Chevy sedans. What's remarkable is how well this system worked in its day, long before the advent of computer-controlled induction in the early Eighties. Developed by Zora Arkus-Duntov and John Dolza, the Rochester Ram-Jet FI is still considered a breakthrough feat of engineering.

With the 20/20 hindsight of electronic fuel injection on modern I S engines, the Rochester unit might seem somewhat rudimentary. Consisting of three basic components - fuel meter, air meter and intake manifold - it keeps a continuous supply of fuel accumulating behind the intake valves, ready and waiting for the valves to open. (The LS engines' precise, computer-controlled, sequential firing of individual Injector nozzles would not become available for many years.)

Instead, on the Ram-Jet, an air metering unit measures how much air is flowing into the intake manifold and instructs the fuel metering unit as to how much fuel should be sent to the engine. Mixing of the air and fuel begins within the nozzles themselves and continues in the cylinder head in the path between the nozzles and the intake valves.

The Ram-Jet is also known for a visually obvious feature, a tall, thin aluminum intake manifold nicknamed the "dog house." Keeping this unit in tune today, though, requires teaching an old dog a few new tricks.

We won't dwell on the intricacies of the design, as that would take an entire hook. (Indeed, for a thorough treatment on the subject, see Kenneth Kayser's authoritative feme, *The History of GM's Ramjet Fuel Injection on the Chevrolet V-8 and its Corvette Racing Pedigree.*) What is of greater interest to owners of these rare, vintage Ram-Jets is how to keep them alive. After all, there isn't a warehouse from which you can readily obtain components. Often as not, replacement parts must be hand-fabricated by technically proficient experts who are hard to come by.

Fortunately, we came across one in Jim Lockwood. an electrical engineer by training but an avid Corvette collector by nature, who works on older fuel injection systems as a hobby of sorts. (Sort of like doing brain surgery in your spare time for fun and relaxation.) He generously shared some of his in-depth knowledge with us, apparently out of good-hearted appreciation for the design of the unit, as he was quick to name fellow 'fuelie' experts who can also be of assistance. We will mention them along the way (see sources listed below), along with troubleshooting tips, and how to repair and/or update specific areas suffering from wear and tear. (Obviously a concern on anything that's more than 50 years old.) After all, keeping this system in tune is essential for enjoyment of a classic Corvette.

While speaking with Lockwood, we also came away with a profound realization of just how intricate and sophisticated the Ram-Jet system is as a milestone of mechanical engineering. As Lockwood put it, "It's the most wonderful mechanical gadget, and does these principles aren't followed assiduously.)

At this point, things can get complicated, as there were several variations on the FI theme, some better than others, which we'll also touch on in the photos. As Rochester Products gained familiarity with the FI system, manufacturing methods were simplified (sand castings became die castings, for example), the subsystem that provides for cold weather enrichment was improved, the subsystem that initiated fuel flow for engine starting was further developed, and eventually attempts were made to increase the FI system's tolerance for hot weather. Despite these changes the fundamental operating principles remained unchanged for as long as fuel injection was in production. The Ram-Jet FI system performed an amazingly good job of metering fuel in a broad range of conditions."

But the devil is in the details, as they say, and fortunately, Lockwood was a saint about guiding us to the better components to use, along with some modern components that can be integrated into the system.

These two views show the "dog house" of the Corvette fuel injection system, the tall, thin intake manifold. The appearance of the 'doghouse' changed somewhat over the years, but not the basics of FI's operation.

Even so, some basics on the care and feeding of this elusive beast are in order. For instance, both the air and fuel meter are sensitive to contamination. A clean 'fuelie' is a happy one. (Note that in 1957, FI was a thenpricey $480.00 option, so no surprise that only 16 percent or 1,040 (284 – 250hp, 713 -283hp, and 43 – 283 AirBox) 1957 Corvettes were fuel-injected, according to the National Corvette Restorers Society.

In addition, as with anyone who's middle-aged, exercising a ‘fuelie’ on a regular basis is probably the best thing you can do for it. Since it's a vented system, sitting still for extended periods of time allows the fuel inside tire fuel meter to evaporate and deposit a film of varnish. This buildup will eventually gum up the works. (Keep that in mind if you come across a dusty "barn find.") Also, it goes without saying that proper assembly and adjustment are essential. (The accompanying photos and captions will illustrate what happens when to improve both its function and reliability, all without hurting the car's collectability. Based on his years of experience, he points out that there are two types of fuel injection systems: those that have failed, and those that are going to fail. He attributes this eventuality to three aspects: wear, engineering flaws and "Bubbas" (all-purpose mechanics who aren't familiar with the subtleties of a Ram-Jet). Lockwood's simple advice: "Look for damage - and don't assume it doesn't matter."

Even when new, the Ram-Jet system was difficult to service and few mechanics had the experience or tools to properly adjust it. Despite their exasperation with it, and preference for simpler and more familiar carburetors, the formerly despised Rochester FI is now recognized as a classic design, and original ‘fuelie’ Corvettes now command much higher prices among collectors.

That's in part because the Ram-Jet was a major improvement over carburetors of the day, and enabled GM to break through the barrier of one hp per cubic inch. Unlike in a carburetor in which the venturi signal directly pulls fuel into the air stream, the venturi signal of the fuel injection tells the fuel meter how much fuel to push (or more accurately, "inject") into the air stream. Because this fuel metering scheme of the FI system was so much better than that of conventional carburetors, the problem of mixture changes due to fuel slosh during hard cornering was eliminated.

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Carburetors also suffered from a limited manifold size due to the requirements of the operating range, and the need for a "hot spot" during engine warm-up. The height of the front cowl, the carburetor and air cleaner had to be low for clearance, and that height restriction interfered with achieving the ideal combination of drivability and high performance.

The Rochester Ram-Jet FI had none of these problems, yet had other issues. Being mechanical, it lacks the sensors that allow modern EFI systems to compensate for a wide range of operating conditions (such as changes in temperature and altitude). Despite this, it does a remarkably good job of adjusting fuel flow in response to changes in air density. Hardcore vintage racers looking for every advantage might find a reason to make minor adjustments right before race day, but for normal street driving, the FI system can be adjusted once and then just left alone. And when that Ram-Jet is working properly, the throttle response can be a memorable thrill.

One particular '57 Corvette needed a quick swap-out of the fuel-injection unit in the pits, in time for a race. NOTE: Dog House is not a 1957.

Take note of the spring inside the enrichment housing. Its inherent strength, and the adjustable tension on it, control when the FI unit switches between a lean, cruising mixture and a rich, power mixture. Three different springs were used between '57 and '65, reflecting increasing experience with FI and reflecting the introduction of more modern cam designs. Install the wrong spring, or improperly adjust even the right spring, and you could end up with a lean stumble or an overly rich bog when accelerating.

Here's the high-pressure pump, disassembled. Inspect the pump shaft for wear, especially near the squared-off end where the lip of a rubber seal typically wears a groove. If there is any question about the condition of the shaft, replace it. Also inspect the end plate (right) for circular patterns created by gear rotation. Lap the end plate on 600-grit sandpaper on a surface plate to remove wear due to gears. Unfortunately, replacement parts vary in quality, so it's important to take note of small details. For instance, a replacement shaft should have a shiny finish, and be of exactly the right size. Even a shaft undersized by .001” can cause free play and allow the tips of the gear to hit the cavity walls.

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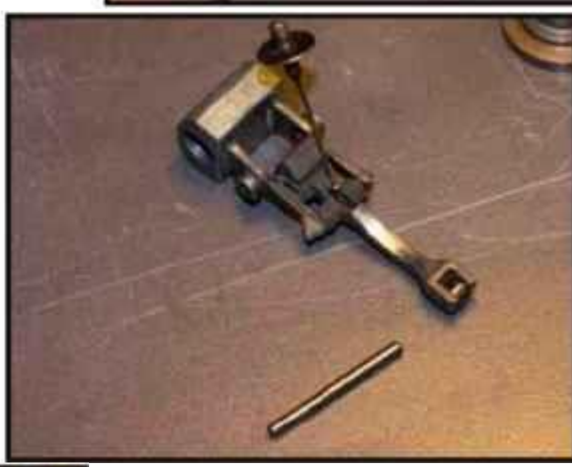
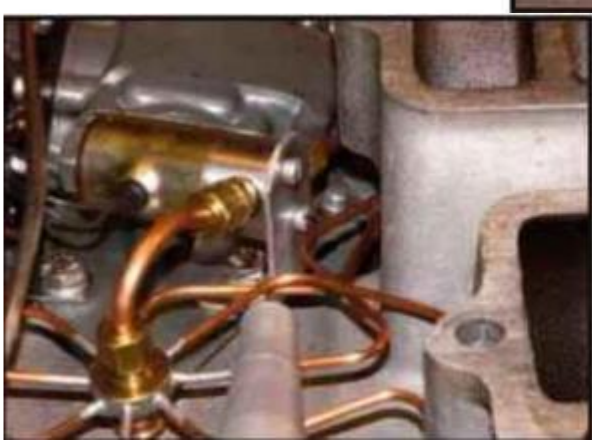
High pressure pump rebuild kits are available from multiple sources, and Lockwood recommends the high quality kits sold by John DeGregory.

Note the wear grooves on the shaft, produced at the lip of the seal. Some shafts can last decades, but not if subjected to debris. Dirt is the enemy of longevity.

As GM gained experience with FI, it was learned that, with the engine off, fuel could siphon out of the bowl and into engine cylinders. The next time an owner tried to start the engine, the incompressible gasoline would lock up the engine. The electric starter, however, was strong enough to keep turning the engine and a bent connecting rod would usually result. GM's solution was to add an internal check-ball in the fuel path as a siphon breaker. Trouble is, experience tells us these can fail without warning. A proven, reliable solution to the fuel siphoning problem is the addition of an electric anti-siphoning valve between the fuel meter and the fuel distribution spider.





Lockwood thinks that it is very important to mount the anti-siphon solenoid valve on a bracket. If the copper fuel lines are used to support the valve, its weight and engine vibration can combine to "work-harden" the copper, causing it to fail and resulting in a serious fuel leak. Note the "spider" (fuel distributor) of copper lines that deliver fuel to the nozzles.

The axle and link assembly is a key mechanism of the fuel metering. Over time, the pivot pin (center) can wear the holes in the counterweight arms into an egg (oval) shape. In extreme cases, such as the one pictured, this wear can permit the roller tip to move sideways far enough to completely clear the top of the spill valve. If this happens, the engine will not run. The jewelry-like axle and link assemblies made by Frank Antonicelli completely solve this wear problem.

Note the mushroom-shaped part (right). Called a "cranking signal valve," it supplies manifold vacuum to the diaphragm (left) during starting. Prone to failure, when it goes bad the fuel mixture gets overly rich, and the exhaust smokes. Lockwood is not a fan of cranking signal valves and prefers to supplement them with a partially concealed electric solenoid valve. This preserves a period-style look but provides improved reliability.

Here's a modern fix for a faulty "cranking signal valve." It's an electric fuel valve used in nitrous systems (NOS part No. 16080).

The axle pin must be free to rotate with no resistance whatsoever. That means no Loctite or epoxy at the ends (shown here) that could add friction.

Look for damage on the business end of the nozzles. If the bottom of the nozzle cup (note pointer) is gone, too much air will enter and lean out the mixture, burning the pistons.

As with other details of the FI units, the "spill valve" which regulates the flow of fuel to the nozzles was refined and improved as time went on.

This one is the earliest and most primitive design. Note the spiral grooves in the plunger (right). If there are any burrs on the grooves, no matter how slight, or if any dirt becomes trapped by them, the plunger can seize within the sleeve.

This second design, generally referred to as the "good guy" spill valve, entered production sometime in 1959 and was a great improvement over the earlier design, hence the favorable name.

The third and final design is known as the "thumbtack" spill valve, due to the shape of the mechanism. This design is, essentially, trouble free. All three spill valves are functionally interchangeable. A unit that has the first design ought to be upgraded with a thumbtack spill valve, but one with a "good guy" spill valve can continue to use it.

Here's something that a rebuilder needs to check: the top of the nozzle has a fairly common problem - a split. This happens because the fuel line nut that screws onto the nozzle was over-tightened by some gorilla who fancied himself an FI expert. It's a compression fitting so the ferrule on the fuel tube wedges itself into the nozzle top, ripping it open. The danger of ignoring such a problem is that a fuel leak and an engine fire could result. Fortunately, new nozzle tops are available. C&C

Fuel Injection Repair Sources

Jim Lockwood (530) 644-2517
Bob Webster (530) 644-1163
John DeGregory (724) 832-3786
Frank Antonicelli (717) 566-5039
Jerry Bramlett, 151 Levert Ave., Mobile, AL, 36607
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http://www.jerrybramlett.net/contact.html
Gary Hodges, (503) 588-3883
P.O. Box 13104, Salem, Oregon 97309
http://www.garyhodgesramjet.com/3301.html
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