RAMJETS THAT RUN!

REPAIR / RESTORATION / CALIBRATION OF '57-'65 ROCHESTER FI SYSTEMS

TECH TIPS **by Jerry Bramlett**

FUEL INJECTION CALIBRATION

Calibrating a fuel injection unit is similar to selecting the right jets, power valve, and accelerator pump cam for a Holley carburetor.

Calibration means positioning the enrichment lever stops so that the unit has the best nozzle fuel pressures for efficient combustion. The two stops have an extremely wide range of adjustment. They can be set to provide nozzle fuel pressures that are much higher or lower than GM recommended pressures. The "economy" stop position controls the fuel pressure at steady cruising speeds. Under acceleration, the enrichment lever moves to the "power" stop to control the nozzle fuel pressure. The enrichment lever will stay on the power stop as long as the car is under hard acceleration.

The blackened horizontal screw on the left is the Economy Stop; the screw on the right is the Power Stop.

One common misconception is that stop positions can be set on a workbench by using a vacuum gauge plumbed to the enrichment diaphragm. Actually, the only way to determine the proper stop positions is to measure the nozzle fuel pressure OR gauge the air / fuel ratio with an accurate exhaust gas analyzer. Both of these methods require the FI unit to be installed on a running engine. Once the stop positions are set, you then use a vacuum gauge to set the length of the enrichment diaphragm rod. The rod length controls when the enrichment lever travels from the economy stop to the power stop. This is similar to setting the timing of the accelerator pump shot on a carburetor.

The calibration will affect the settings of the other adjustable features on your fuel injection. In other words, you must properly calibrate a unit before you set the idle mixture, choke position, etc.

These are the other adjustable features that allow each Rochester FI unit to be custom tuned to work properly with a particular cam grind and engine displacement.

1. Idle speed (idle speed screw)
2. Idle fuel mixture (idle mixture screw)
3. Fast idle speed (fast idle speed screw)
4. Cold enrichment / choke fuel mixture (bakelite cover / choke butterfly position)
5. Timing of enrichment lever movement (enrichment diaphragm rod length)

INSTALLATION, START-UP, AND MAINTENANCE

It's important to use top quality parts in your ignition system. I recommend installing a new Delco plug wire set. I never use those "properly dated" reproduction plug wires because of their tendency to misfire under load. I prefer to use new ignition coils rather than 40 - 50 year old GM originals. You can buy new plug wires from K&B Special Products near Atlanta. Their phone number is (770) 777-1031. The Pertronix 1.5 ohm coils fit in original Corvette coil brackets and work properly with a stock low-resistance ballast resister. An excellent spark plug available today for injected Corvettes is the Autolite #295. This plug is a non-resister design equivalent to the discontinued AC 46.

You can easily break the mounting ears on the 1963 - '65 plenum feet by over-tightening. Do not apply more than 5 ft-lbs. of torque to the hold-down nuts when installing the plenum on the adapter manifold.

When replacing the '63 - '65 plenum cover seal, use a soft rubber reproduction version. Do not use a rigid seal like those installed by GM. A hard seal will not conform to the shape of the plenum and can cause the cover to crack when it is fastened down.

Use black RTV silicone sealer on the engine block at the ends of the adapter manifold rather than the pre-formed rubber or cork seals that come in intake manifold gasket sets. This reduces the risk of cracking the corners of the manifold. Tighten the manifold-to-head bolts to no more than 25 ft-lbs. I usually tighten the front bolt on each side to 5 ft-lbs. less than the others. Also, use silicone sealer around the water jacket openings in the cylinder heads where they mate to the adapter manifold.

This is a Piston Stop Tool made from an old spark plug and hardware store nuts/bolts.

Confirm that that the Top Dead Center mark on the harmonic balancer is properly matched to the "0" on the timing chain cover scale. Chevrolet offered high performance small block balancers with the timing mark in several different locations over the years. You can check the location of your TDC balancer mark by using a piston stop tool.

If your distributor has a vacuum advance canister, it should be disconnected while setting the timing. You should make sure the total amount of mechanical advance is 36 degrees at high rpm. You'll probably find that 8 degrees of initial advance will give you 36 degrees total in a '57 FI distributor. The '58 - '65 distributor *initial* timing when using either the Duntov "097" cam or the later "30-30" cam should be 12 - 16 degrees.

If you're installing a 7017380 series unit, remember to plug the purple wire into the micro-switch. It also plugs into the ignition harness just above the windshield wiper motor. If you forget to install this wire, the engine will not start.

Check to make certain the throttle butterfly is fully open when the accelerator pedal is pressed to the floor. The accelerator linkage rod length is adjustable.

Make sure the bellcrank return spring is strong enough to fully close the throttle butterfly every time. Some reproduction pull-back springs are too weak to work properly.

If a quick first time start-up is important to you, pre-fill the fuel bowl through the top vent before installing the unit. You will have to remove the top fuel meter bracket and screen first in order to do this.

Modern gasoline has a relatively low boiling point compared to gas sold during the sixties. If you experience a rough idle due to percolation (gas boiling in the distribution spider), use undiluted racing gas instead of pump gas. Racing gas has a 50% boil-off temperature over 210 degrees. Aviation gas won't fix a percolation problem. It has about the same 50% boil-off temperature as pump gas, which is often as low as 150 degrees. Blends of racing gas with pump gas don't seem to help either.

After the engine has warmed up, hold the accelerator pedal at least 3/4 to the floor while turning the key to start. This prevents flooding.

Always start and drive your injected car at least once a month. Keep fresh gas in the tank. Pump gasoline has a shelf life of about one year. Racing gas has stabilizers that allow it to last much longer.

If your unit has a cranking signal valve, assume it will be the next FI part to fail. The primary symptom of CSV failure is an excessively rich fuel mixture.

Always carry a spare gear pump drive cable with you. You may never need one, but if you do break a drive cable on the road, your engine will not run until you replace it.

SHIPPING A FUEL INJECTION UNIT

Rough handling by a parcel delivery service can do more damage to your FI unit in 2 seconds than you will cause by driving it hard for thirty years. The best way to protect your FI system is to "double box" it yourself before shipping. Double boxing is not difficult or expensive; it just takes some additional time.

U-Haul Moving Centers sell cardboard boxes in several large sizes.

First, empty all the gas from the fuel meter by turning your unit on its side. Then pack the unit inside a cardboard box that fits fairly close around it on all sides. Ship the plenum mounted on the adapter manifold. A good box for this is sold by U-Haul Rental Centers. This box is 22" x 15" x 12", and U-Haul calls it a "Legal Tote Box". Fill the open spaces inside this box with bubble wrap or wadded up paper so your FI unit can't move around. Do not put any Styrofoam packing peanuts inside the box with the unit.

Next, place the distributor (less cap) inside its own tightly fitting cardboard box. It's very easy for the iron and steel distributor parts to nick and scratch the aluminum parts of your unit if you don't put the distributor in its own box.

Now place the distributor and FI unit boxes inside a large box that will hold them both. The U-Haul size appropriate for this is 24" x 24" x 18". It's called an "Extra Large Box". The two inner boxes should fit inside the outside box with at least an inch of open space on each side. Fill the open spaces between the inner boxes and outer box with Styrofoam packing peanuts.

Packing supplies such as cardboard boxes, bubble wrap, and packing peanuts are sold at almost all FedEx Office stores as well as U-Haul Moving Centers.

Personally, I prefer to use FedEx Ground. I've never had to file a damage claim with them, and their delivery times are usually no more than 3 or 4 days from anywhere in the continental U.S.

If you're shipping an FI unit to me, please use my residence address: Jerry Bramlett, 151 Levert Ave., Mobile, AL, 36607.

ROAD TESTING VS. STATIONARY TEST ENGINES

For many years I used a stationary Corvette engine on a test stand to calibrate fuel injection units. While I was always able to calibrate units to GM specifications using this set-up, some running problems didn't show their symptoms at all while the unit was being tested.

I decided several years ago that stationary testing wasn't good enough for my customers. No FI owner wants to be turned into a test monkey by his mechanic. I needed to be certain that I had found and corrected all running problems before I shipped an FI system back to its owner.

Always use an air cleaner when calibrating or testing an FI system. Without any air cleaner, the fuel mixture will be about 10% leaner than with an air cleaner.

An engine must be under a heavy load to fully test the performance of the FI system. For example, on an unloaded stationary engine an FI pump with excessive gear clearance will provide enough fuel to rev the engine to 5,000 rpm. However, in a 3000 pound Corvette test car, a pump with loose gears will cause the engine to fall on its face when you floor the accelerator pedal. There really isn't a practical way to simulate every effect of car acceleration on the FI system other than to install it on a Corvette and drive it hard.

My testing program includes driving every FI system I repair under real-world conditions. I also use an instrumented chassis dynamometer to check the air/fuel ratios of each unit under acceleration and cruising loads. To handle this testing I maintain three Corvettes set up to receive customer units and distributors. Two are 1963 convertibles. The third test car is a '57 model.

I keep my own FI adapter manifolds installed on these test cars. That way I can quickly install and remove the customer's unit and distributor without draining any engine coolant. My road testing includes some cold engine operation as well as some steady speed cruising after warm-up. The toughest test of any unit is hard acceleration through at least three gears, and I perform this test at least twice.

I've learned a lot through my road testing program. I doubt I would have ever encountered some of the FI problems I've had to solve if I had just kept using that stationary engine test stand.

COLD ENRICHMENT / CHOKE DESIGN PROBLEMS

Let's face it… GM never did get the cold enrichment system design quite right for the '57 - '65 Corvette fuel injection units. They did come close with the '63 - '65 hot air choke design, but even that one needs help to work properly.

The design of the '57 - '61 cold enrichment mechanism was an evolving bad joke. It worked as well as a broken clock; it would be right occasionally, but not very often. Its biggest problem was the on-or-off way it richened the A/F mixture.

The cold enrichment came on and went away in one distinct, rather than many gradual, steps. Initially no vacuum would be sent to the fuel meter enrichment diaphragm. This kept the lever parked on the power stop during the first minute of operation. The result was a super-rich mixture until the enrichment lever was allowed to swing over to the economy stop.

This is a '58 - '61 cold enrichment housing with the bakelite cover assembly removed. The piston on the left cuts off vacuum to the enrichment diaphragm when it is fully extended. The larger piston on the right sends a vacuum signal boost to the main diaphragm when it is depressed.

This system used an electric heat coil to control activation. This coil usually cooled off much faster than the engine block. When an owner would re-start his car after letting it sit only 20 - 30 minutes, the cold enrichment system would be activated although the warm engine didn't really need an over-rich mixture.

The first true "choke" type FI cold enrichment system was introduced in 1962. It featured a butterfly plate in the air meter controlled by an electrically heated coil. While it did come on and go away in a gradual motion, it was problematic too. The coil still cooled off faster than the engine. A new problem was introduced as well. The steel butterfly plate was installed on a relatively flexible aluminum shaft. That shaft passed through four (count-'em) four holes in the pot metal venturi cone. Over many heating / cooling cycles the pot metal cone would warp. This would throw the four shaft holes out of alignment, causing the butterfly shaft to bind.

Chevrolet finally went to an exhaust heat controlled choke in 1963. This made the choke activation more a function of true engine heat. The steel choke butterfly was still installed on an aluminum shaft. In this design it passed though "only" three holes in the pot metal venturi cone. However, the shaft would still bind due to changing dimensions after many heating cycles. A new problem was the over-rich mixture caused by the butterfly being too restrictive to air flow when the choke was fully engaged.

I believe GM tried to correct the '63 - '65 choke over-rich problem by selling an "FI Choke Modification Kit" at their parts counters. The kit included a choke pull-off piston to be installed in the choke housing, a more aggressive fast idle cam, and a weaker bimetallic spring on a new choke cover. This kit is best remembered for introducing a new problem. Engine manifold vacuum would move the pull-off piston down when the engine was running. This piston motion would hold the choke butterfly open against the closing force of the bimetallic spring until the spring warmed up. However, carbon / dirt would build up in the piston bore and eventually cause the piston to stick.

There's really not much you can do to improve the operation of the '57 - '61 FI cold enrichment systems. I'll admit they will work adequately to get you down the road when the engine is cold. You'll just have to tolerate the over-rich mixture they produce initially.

You can make several simple improvements to the '62 - '65 choke systems. First, you can align-bore the choke shaft holes in the venturi cone slightly over-size. This will allow the aluminum butterfly shaft to rotate freely again. I would also recommend buying a reproduction butterfly plate and cutting a large window in it. This will effectively lean out the mixture when the butterfly is closed without having to endure the hassles caused by installing a sticking pull-off piston in the choke housing.

MODERN PUMP GAS ISN'T GOOD ENOUGH

Until November, 2011, I used pump premium gasoline for all my road testing and calibration work. Occasionally I'd get a bad tankful at some station and have to replace it with a different brand, but that happened only once or twice a year. Unfortunately, I consider those years the "good ol' days". Today the pump premium sold here in Mobile is unacceptable for use in Rochester injected Corvettes. Now I use undiluted racing gas exclusively in my test cars.

On a '57 - '62 unit, make sure there is an air gap between the top of the spider hub and the bottom surface of the plenum.

Modern pump gas can cause FI running problems throughout the RPM range. You're probably familiar with the poor idle caused by percolation (boiling) of pump gasoline in the distribution spider. You may not have heard about the problems it causes during cruising and at high rpm though. Those problems are a little tougher to detect.

It took four hours on the chassis dyno for me to understand the Air / Fuel ratio differences between running modern pump gas and true racing gas. I was in shock by the end of that test session. I found that pump gas burns much leaner at idle (below 1,000 rpm) and high rpm (above 4,000 rpm) during hot weather than racing gas. Oddly, pump gas burns richer than racing gas at legal cruising speeds (30 to 70 mph). This means that although your car *will run* on pump gas, it won't run its best. In the summer your idle will be rough after the engine is fully warm, and you'll foul spark plugs more frequently while cruising. This also means sustained engine operation (many minutes) at very high rpm (above 5,000 rpm) with pump gas could burn a hole in a piston or a head gasket on a hot day.

Here's my opinion why modern pump gas doesn't calibrate properly in old Rochester FI units. Gasoline is a mixture of many components. These components have different physical characteristics. Some are "light ends", and vaporize at relatively low temperatures at atmospheric pressure. This fact isn't apparent when you see the published vapor pressure of gasoline because ***it's an average for the entire mixture***.

At idle, the distribution spider is only pressurized to 0.25 pounds per square inch. This is very near atmospheric pressure. A significant portion of modern pump gasoline will vaporize inside a ***hot*** spider hub at such a low pressure. This causes the Air / Fuel mixture at the nozzles to go lean. It may not be lean enough for your seat-of-the-pants gauge to detect, but I can certainly see it going lean using the dynamometer control panel instrumentation.

The high speed lean-out is caused by a similar, but different, vaporization problem. All pumps need a certain amount of feed pressure on the suction side to maintain liquid flow at the design pumping rate. If this feed pressure (called "Net Positive Suction Head") is less than required by the pump design, the incoming liquid will partially vaporize into bubbles. It's called "pump suction cavitation" when this happens. Bottom line: a pump that doesn't have enough Net Positive Suction Head will not flow as much liquid as it should.

The amount of Net Positive Suction Head is determined by the height of the liquid feeding the pump suction side ***and*** the physical properties of that liquid at pumping temperature. ***Hot*** modern pump gasoline less than 3" high in the fuel bowl doesn't provide squat for NPSH. I can see exactly when gear pump cavitation starts while watching the dyno control panel. On a hot day, it can occur as low as 4,000 rpm under full acceleration load. It only gets worse as the rpm's climb. By 5,000 rpm, cavitation can cause a mixture as lean as 18:1. That's lean enough under load to hurt some engine parts if you don't take your foot out of it.

Pump gas burning richer than racing gas while cruising is not a big shock to me. After all, octane rating is often indirectly related to volatility. Because it is more volatile, I believe modern pump gas burns more efficiently than racing gas at relatively low engine compression ratios. Running slightly rich while cruising won't cause any major problem. It may foul spark plugs a little sooner than running the right A/F ratio, however.

You can run 100LL Aviation gasoline, but it won't help much. Those special gasoline additives sold at auto parts stores don't have any significant effect either. Neither does the additive sold at swap meets that is 99% kerosene. I've tried the thick, one-piece, plenum to baseplate gasket too. It was no help. Insulating the gas line from the engine fuel pump to the FI fuel meter makes things worse. The best course is to just run 100% racing gas. I use the VP brand with a 110 octane rating, but other brands of racing gas would probably work just as well. I tried cutting it 50% with pump premium to save money, but the running problems were still there.

CLIFF'S VERSION: Your FI unit will start and cruise on modern pump gas, it just won't idle consistently at 800 rpm or perform its best **in hot weather** unless you run racing gas. This is due to pump gas boiling in the spider. I know of no FI modification or fuel additive that will completely prevent pump gas boiling at very low nozzle pressures during hot weather.

'63 - '65 SPIDER DESIGN PROBLEMS

I believe GM was very aware of the spider percolation problem in early Rochester FI units. They tried several fixes to eliminate the problem. The first was to isolate the spider from the heat radiating upward from the adapter manifold. In 1957 and most of 1958 fuel injected Corvettes were fitted from the assembly line with a thick, one-piece cardboard gasket / heat shield between the plenum and the adapter manifold. This proved ineffective, so the large gasket wasn't used on later units. The next cure they tried did have some positive effect on the idle percolation problem, but it also introduced a new problem that wasn't apparent for several years.

In 1963 the gas feed circuit to the distribution spider was made into a loop. Instead of getting gas that had been through the spill valve, the spider now received only some of the gas from the gear pump while it was on its way to the spill valve. This new design circulated more of the relatively cool gasoline from the fuel meter through the spider hub. I think that's why the '63 - '65 FI units don't have as bad an idle percolation problem as the pre-'63 units.

These are the parts inside a 1963 - 1965 spider center hub. If that tiny, weak spring ever loses its tension or gets gummed up, the spider will perform poorly.

The down side of this spider feed loop arrangement is its effect on the spider hub design. The anti-siphon needle valve was gravity operated from 1957 through 1962. In 1963 though, gravity could not be used. The spider hub had been inverted to make more room for the fuel supply loop. This made the hub needle valve "upside-down". A tiny spring had to be installed below the needle valve to shut it when the engine was turned off. This new spring-loaded needle valve design had an unintended effect: it provided a variable resistance to gas flow into the spider. The more the spring was compressed by gasoline flow, the more backpressure it produced. The previous gravity-operated needle valve had a constant amount of backpressure essentially equal to the weight of the needle valve.

I believe this variable resistance of the spider hub spring was properly considered in the engineering design of the '63 - '65 FI units. However, the manufacturer of these tiny springs probably didn't have good quality control. I believe that many spiders were assembled with springs that had significantly different spring rates than what GM specified. I believe this because about 30% of the '63 - '65 spiders that I check flunk one of my driving tests.

I call this my "freefall-to-idle" test. It works like this. [WARNING: Do not try this in your driveway.] After warming up the engine, I stand on the accelerator pedal through three gears. I then suddenly take my foot off the accelerator pedal and disengage the clutch at the same time. This allows the engine speed to freefall from about 5,500 rpm to an 800 rpm idle without any resistance from the drivetrain. At this point the FI system has been running full rich for about ten seconds. It has fully compressed the spider hub needle valve spring during that period. Now the FI system has to immediately create a much leaner mixture. The spring has to extend to the precise location necessary to support an idle. Evidently that's a hard test for an imperfect spider to pass. If the spring is defective, the resulting idle mixture will immediately be too rich or too lean and the engine will die.

CRANKING SIGNAL VALVE STARTING PROBLEMS

Almost all fuel injected Corvettes with starting problems are equipped with Cranking Signal Valves. The CSV is an ingenious device that just doesn't work very reliably in the real world. It is designed to pass about 1" water of manifold (plenum) vacuum to the main diaphragm to make an FI unit squirt gas from its nozzles during engine cranking. When the engine starts and the plenum vacuum jumps above 19" water (1.4" mercury), the CSV is supposed to shut tight. Well, that was the original theory anyway. Early FI Corvette owners quickly found that the CSV could suddenly fail with no warning. However, it almost always failed partially open. This allowed too much plenum vacuum to the main diaphragm, making the FI unit run very rich. Once a CSV failed you could still start the engine, but it would run so rich it wouldn't idle properly.

A Corvette engine with the 097 "Duntov" camshaft can make as much as 22" water vacuum in the plenum while cranking IF the throttle is fully shut and the Cranking Signal Valve is not bleeding off any vacuum to the main diaphragm. However, these aren't normal cold starting conditions for FI engines. Usually the throttle is partially open because of the fast idle cam position. Also, the Cranking Signal Valve is letting some of the plenum vacuum go to the main diaphragm. Under typical cold start conditions for FI engines, the plenum vacuum varies in rapid pulses between 4" and 7" of water. This lower-than-optimum plenum vacuum is actually a good thing. If the plenum vacuum was over 14" water, the Cranking Signal Valve would be essentially shut and should not pass enough vacuum to make the FI unit squirt any fuel from the nozzles.

If your Corvette won't cold-start immediately after a three second blast of ether, then the problem isn't in the fuel injection unit.

You're probably wondering how much vacuum is required at the main diaphragm for an FI unit to shoot a steady stream of fuel from the nozzles at cranking speed (150 - 200 rpm). The answer may surprise you; it certainly did me when I tested two units to find out. Only .5" to .7" water vacuum is needed at the main diaphragm during cranking to generate a good fuel stream at all nozzles. That's not very much vacuum. Engine manifold (plenum) vacuum is normally measured in inches of mercury. One inch of mercury vacuum equals 13.6 inches of water vacuum. This means that plenum vacuum during a normal cold start is less than .5" mercury, and that only about .07" mercury vacuum is passed by the CSV to the main diaphragm.

My tests of Cranking Signal Valves were also a little surprising to me. I found that the plenum vacuum passed by these valves is extremely low. Under normal cold engine cranking conditions (rapidly pulsing 4" - 7" water plenum vacuum), most good cranking signal valves will pass about 1" water vacuum. The dozen CSV valves I tested passed the highest vacuum to the main diaphragm when the plenum vacuum (at the threaded CSV nipple) was only 2" water. Above that plenum vacuum level, the vacuum passed by the CSV went down quite rapidly. Most good CSV's stop passing any significant vacuum at about 14" water plenum vacuum.

I believe these are the leading causes of CSV equipped FI engines failing to start quickly when cold:

1. A low gas level in the fuel meter bowl.
2. A tiny vacuum leak at the main diaphragm or in the signal tubing connections above it.
3. Too much liquid gas in the cylinders (liquid gasoline won't explode, it has to vaporize first).
4. A spill valve that is not fully seated (causing it to sit low in the fuel meter casting).
5. A very slow engine cranking speed (not generating enough plenum vacuum).
6. Too much plenum vacuum during cranking (shutting the CSV).

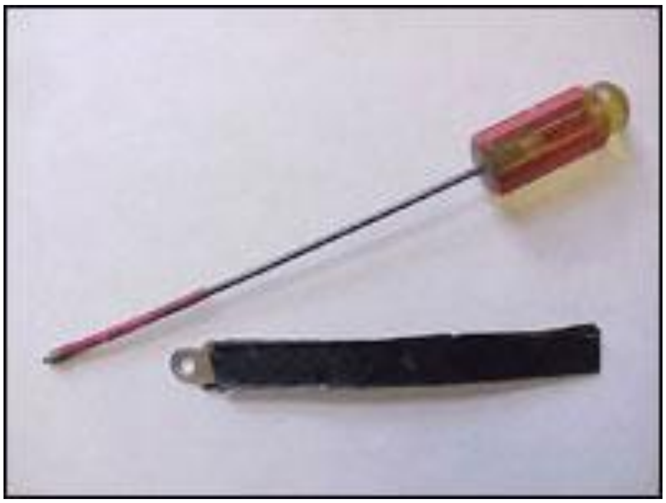
HOMEMADE FUEL INJECTION TOOLS

Over the years I've constructed four special tools to help me work on fuel injected Corvette engines. None of them are high tech, but they still save me a lot of time.

- **Tool #1: Enrichment Stop Adjuster**

  The most helpful tool I've built is a 3/32" hex-head screwdriver with a flexible shaft. I use it to adjust the fuel meter enrichment lever stops while a unit is running. The Chevrolet shop manual implies I could use an ordinary 3/32" Allen wrench (hex key) to change these screw settings. Riiiiiiight! Perhaps some people can do this easily with an L-shaped hex key, but I can't do it without becoming extremely frustrated. There is very little room to work between the plenum and the fuel meter. I have to lay on top of the engine to see where to put the hex key. Even then, my stubby fingers can only rotate a stop screw an eighth turn at a time with a hex key.

The flex-shaft tool really shortens the time it takes me to recalibrate a fuel injection unit using a manometer. I no longer have to start and stop the engine multiple times while searching for the right setting on each screw. I can now insert this tool into a set-screw and just leave it there until that screw is properly set. The hex head will stay in the set-screw by itself, even with the engine vibrating. I use one hand to hold the throttle at ½" venturi vacuum while I make quick adjustments to the stop screw with the other hand. I can keep my eyes on the manometer the whole time.



The steel strap with a hole in one end helps guide the stop adjuster tip into place.

This is the tiny hex head tip of the Enrichment Stop Adjuster tool.

I didn't buy many new supplies to make this tool. I used a short section of old speedometer cable for the flex-shaft and the remains of a broken screwdriver for the handle. I also used the hex tip from a carburetor adjusting tool kit I bought for about $12. This kit is available from the Lisle Corporation under part number 55250 at CarQuest stores. It contains a flexible-shaft driver with four interchangeable heads. The adjusting tool supplied in the kit can't be used on fuel injections because the shaft is too stiff to reach the set-screws. Also, the 3/32" hex head is too long as furnished to maneuver into place. The head must be cut down to a much shorter length and then attached to a more flexible shaft such as the speedometer cable I used. This hex head is made from very tough steel. A Dremel tool or high-speed grinder must be used to cut it. A hack saw won't work. I drilled a shallow hole in the back side of the shortened head in order to securely epoxy the cable tip. Probably any type of industrial-strength epoxy will do. I used the "J-B Weld" brand I found at the auto parts store. To protect the plenum from scratches when the tool is used, I enclosed part of the cable in heat-shrink tubing.

- **Tool #2: Oil Line Wrench**

This tool is a custom-shaped wrench for removing the oil line going to the distributor. I started with a 3/8" flare nut wrench. I shortened the handle and then bent it 90 degrees. Tool steel is impossible to bend cold, so I heated the handle cherry red with a cutting torch first. After the wrench cooled I glued the handle stub into an old 3/8" drive socket with more J-B Weld epoxy.

- **Tool #3: Oil Seal Remover**

  Gene Dressen gets the credit for designing this tool as well as Tool #4. He described them in a *Corvette Restorer* article during the late seventies.

  The distributor oil seal remover is just a screwdriver shaft with a reshaped blade. With it you can drive out oil seals from the backside. I made mine by using a Dremel tool with a cutoff wheel as a grinder. I removed the screwdriver handle because it was too soft to hammer, and then bent and recontoured the shaft tip so it would push squarely on the seal metal lip.

Oil Line Wrench

Distributor Oil Seal Remover

Distributor Oil Seal Installer

- **Tool #4: Oil Seal Installer**

  This tool is a long bolt with several nuts and washers for pulling a distributor mainshaft oil seal into place. The large nut acts as a slip collar to protect the top of the distributor while the bolt and small nut are turned with wrenches.

CAMSHAFT CONSIDERATIONS

I'm often asked if a Rochester injection system will work properly on a highly modified small block. The key to the answer is the camshaft used. That's because a Rochester FI system uses engine rpm, plenum manifold vacuum, and air meter venturi vacuum levels to determine how much gas to squirt from the nozzles. The injection unit doesn't know what displacement engine is sitting under it. The injection doesn't really care about the compression ratio either. However, the unit **does** know and care how hard the engine is sucking on the manifold runners at all running speeds. And, the engine vacuum / rpm curve is primarily determined by the profile of the cam lobes.

It's possible to redesign the axle link, spill valve, enrichment lever, and idle vacuum signal systems to work with a very radical aftermarket camshaft. Well, at least it's possible in theory. It's certainly not practical though, and I'm not about to attempt to do it for a customer. It makes much more sense to me to confine engine modifications to installing better flowing cylinder heads and a using a larger displacement block. I would definitely install a mild camshaft with a near-stock profile if I was going to use Rochester fuel injection. By mild, I mean a cam that produces at least a steady 12 inches of mercury vacuum in the plenum at an 850 rpm idle speed.

Chevrolet used two different high performance camshafts with Rochester fuel injection on the assembly line. The first of these cams, used in '57 through '61 283 engines, was the "Duntov" or "097" solid lifter design. This same cam was also used in the '62 - '63 327 fuel injected Corvette engines. I know through my own testing that the 097 cam will produce 13 to 14 inches of vacuum at an 800 rpm idle **IF** the lash is set at .012" on the intake and .018" on the exhaust valves.

Chevrolet used a much more radical cam in the '64 - '65 327 fuel injected engines. This cam is known as the "30-30" or 375hp solid lifter cam. This cam usually produces about 12 inches of steady vacuum at 850 rpm if the lash is set at .030" and .030". I say "usually" because some modern aftermarket versions of this cam require more lash than .030/.030" to reach this level of vacuum. Some brands need as much as.035" lash on both intake and exhaust valves to make acceptable vacuum at low engine speeds.

These two cams aren't the only grinds that will work with Rochester FI. The old 327/350hp hydraulic cam will work just fine too. So will the 1970 - '72 LT-1 solid lifter cam. There are probably many more acceptable cams that I haven't ever tried. Just remember to check the plenum (manifold) vacuum level at an 850 rpm idle speed to determine if your cam is making enough vacuum to use Rochester injection. If you come up with less than 12 inches, then you're going to have a drivability problem that will be extremely hard to ignore around town. Out on the freeway it won't make a significant difference in driving sensation. So, if you insisted on using a radical cam in an injected engine, I guess you could just keep the revs over 3,000 all the time. Yeah.....now THAT'S the ticket for a relaxing cruise around town!

CHEVROLET FUEL INJECTION DISTRIBUTORS

Over the nine model years that Chevrolet offered Rochester fuel injection, they assembled 12.5 different V-8 distributor designs to drive the fuel meter gear pumps. The extra "half design" was a slightly modified service distributor that bore the same part number as the 1111070 assembly line distributor. All of these distributor designs will work with any Rochester '57 - '65 small block Chevrolet FI system. However, some of the designs had features that make them less than perfect for today's driving.

This information was compiled with the help of Don Baker. I consider Don the leading expert on Rochester FI distributors. His machining skills are unmatched. When I encounter a distributor that needs more repair than I can provide, I send it to Don. You can contact him in Sandwich, Illinois, at (815) 498-9522.

- **1110889** -- This dual point distributor was the first design used with the 283 horsepower fuel injected Corvette engines in 1957. It had no vacuum advance mechanism or tach drive coupling. It's weak point is the unsealed bearing that was used at the top of the mainshaft. Chevrolet received owner complaints about oil-fouled points shortly after it hit the streets. Their solution was to replace the 889 with a new distributor, the 1110905. It's very difficult to find an 889 FI distributor in use today. I doubt any 889's were installed on the assembly line after December, 1956. Also, many 889's installed in 1956 were quickly replaced with 905 distributors during 1957 while under warranty.

- **1110905** -- The 905 distributor was identical to the 889 with two exceptions. It had a larger drain hole to take the oil away from the upper gear chamber, and it had a sealed upper mainshaft bearing. It still had dual points that were not externally adjustable, no vacuum advance, no tach drive, and a two piece main body that allowed advance adjustments without rotating the distributor base at the manifold. The 905 distributor design was used in almost all of the 1957 model year 283 hp engines.

- **1110906** -- The 906 was the first FI distributor designed for use with an automatic transmission. It was installed during the 1957 model year only. It had single points that were not externally adjustable, and it had no provision for tach drive. It also had a vacuum advance mechanism with a hexagonal canister (stamped 125) and a threaded vacuum hose connection. The 906 upper housing looked very similar to that of the 905. However, the 906 upper housing was about 1/4" taller to accommodate a slot for the vacuum advance canister. This taller housing required a taller distributor mainshaft. The 906 point cam was also different from the 905 version. It used a slightly different rotor orientation for the single set of points. Beware of those who offer a 906 that has been "converted to 905 specs". This conversion can certainly be done, but proper a conversion requires much more than filling the advance canister slot with Bondo and installing a mounting plate for dual points.

- **1110908** -- The 908 design was the first FI distributor to have a mechanical tach drive coupling. The cable end design (required to mate with the distributor tach drive cross-shaft) was round with a "tang" or ridge projecting from the side. Except for the tach drive, the 908 distributor was very similar to the 905 design. It had dual points that weren't externally adjustable, and no vacuum advance. Many believe that the 908 was first installed on the 1957 "air box" 283hp Corvettes to drive their steering column mounted tachs. I believe that most 908 distributors were installed on early 1958 Corvettes with the 290 hp injected engine.

- **1110914** -- This distributor was used in 1958 through 1961 solid lifter FI engines. It had externally adjustable dual points, a tach drive coupling, and no provisions for vacuum advance. The mainshaft top cam (or "football") was stamped with the number 42. The points cam was stamped 122. The mechanical advance weights were each stamped 37, and most of these weights had an "extra" small hole in their heavy ends. The upper housing of the 914 distributor used a much smaller diameter clamp (than previous FI distributors) to hold it tight against the lower housing. This smaller clamp design was used for all later FI distributors. Beginning with the 914 model, all FI distributor lower housings had a removable square data plate which allowed quick inspection of the cross-shaft drive gear while the distributor was mounted in the engine.

- **1110915** -- This distributor was used in all the 1958 through 1961 FI engines with hydraulic cams. It had externally adjustable single points, vacuum advance canister #134, and no provision for a tach drive. In place of the tach drive coupling was a hex-head plug. This distributor was the only FI design with a manual oiling tube projecting from the side of the main housing. This tube provided oil through cotton wicking to lube the upper housing vertical hub surface. The mainshaft top cam was stamped 73. The points cam was stamped 726 or 728. The distributor weights were unmarked and were the same as those used in passenger cars.

- **1110990** -- This dual point distributor was used only in very early 1962 model FI engines. It had no vacuum advance, and the points were externally adjustable. The mainshaft cam was stamped 54. The points cam was stamped 722. The advance weights were stamped 37, and most had the heavy end holes mentioned previously.

- **1111011** -- This distributor was used in all of the later 1962 FI engines. It was identical to the 990 distributor design (dual points, mainshaft cam #54, advance weights #37) except it sometimes used a points cam stamped 724.

- **1111022** -- This distributor was used in all 1963 FI engines. It was identical to the 011 (mainshaft cam #54, advance weights #37, points cam #724) except for these three features: the 022 used single points, it had a felt wick in a plastic stand for oiling the point cam, and it had a vacuum advance mechanism. The advance canister was stamped 201 15. The canister had the modern conical shape with a smooth nipple for the hose connection. This canister required a relatively high amount of vacuum for full advance. The hose from the canister was attached to a "ported" connection on the air meter that did not provide vacuum at idle.

- **1111063** -- This distributor was used with the 7017375R series FI systems that were installed in early 1964 model injected Corvettes. It was identical to the 022 model (single points, vacuum advance, felt wick for point cam, mainshaft cam #54, advance weights #37, point cam #724) except for the advance canister used. The 063 advance canister was a low-vacuum design stamped 236 16. The hose from it was attached to a full-time vacuum connection on the plenum.

- **1111064** -- This distributor was the only model installed with the '64 - '65 FI transister ignition system. It used the following parts: advance canister 236 16, mainshaft cam #03, un-numbered advance weights with a hole in the heavy end, and magnet rotating cam #736 (or possibly #540 or #542). The cap used with this distributor still had the little sliding door for external access to adjust points.

- **1111070** -- This distributor was used with most, and possibly all, '64 and '65 7017380 series injection units. The assembly line version had a 236 16 vacuum canister, a felt wick for the point cam, mainshaft cam #03, point cam #732, and un-numbered advance weights with a hole on the heavy end. Sometime after fuel injection was dropped as a production option, the service versions of this distributor were changed slightly. The felt wick for oiling the point cam was changed to a foam donut on a plastic stand. Also, the point cam was changed to a number 536 and the mainshaft cam became an 03W or had no stamped number at all. Most of the distributor weights used in the service distributors lacked the extra holes in the heavy end.

THE SHOCKING TRUTH ABOUT CALIBRATION ACCURACY!

Click to enlarge scanned sheet.

Chevrolet first printed "Form 1514C, Fuel Injection Specifications" in July of 1965 to document tuning info for all the FI model series from 1957 through 1965. Fuel injection mechanics have been using this one page data sheet as their primary reference source for calibration settings ever since. At first glance it seems to have all the data needed to calibrate a Rochester fuel injection system installed on a stock Corvette engine. Well, except that a lot of the stop settings listed are nonsense.

Frankly, I have no idea how most of the recommended nozzle pressures listed on that sheet were determined. I've never seen a GM or Rochester chart showing the nozzle orifice sizes originally installed in the 19 different FI model series. I think having such a chart is essential to understanding why the author of Form 1514C thought the calibration pressures he listed were appropriate. I've found through my own hot testing that some of those listed set pressures just don't work well.

Engine displacement, compression ratio, camshaft grind, and engine load pretty much determine the nozzle discharge volume needed at any particular rpm. Then, once you pick a nozzle orifice size, it's a relatively straight-forward calculation to determine how much fuel pressure at the nozzle inlet is optimum for each enrichment lever stop setting. So.... why did the author of Form 1514C list so many different stop settings for different unit series that were installed on nearly identical 283 engines with nearly identical nozzle sizes? It doesn't make any sense that a '57 7014520 series FI with Q nozzles should have stop settings about 50%

higher than a '58 7014900R unit with Q nozzles **when they are both mounted on 283 engines with the 097 Duntov cam.**

My biggest objection to GM's "nozzle pressure" calibration method is that it doesn't produce consistent air / fuel ratios from unit to unit. I believe this is the result of two quality control (or engineering design) issues that Rochester never addressed. Most importantly, I suspect the fuel meter gear pumps produced by Rochester NEVER had identical performance curves, even when they were new. Now that they have about fifty years of wear on them, I think the output of each pump varies considerably. Also, consider this: the nozzle orifice discs were manufactured from very thin stainless steel. These discs "take a set" when first subjected to high gasoline pressure on one side. They inelasticly deform, in other words, and that uniquely affects the shape, volume, and pressure of the fuel spray coming from each nozzle.

I've found that the only way to ensure correct air / fuel ratios is to calibrate every unit on a hot engine using a chassis dynamometer. I've been doing this with each unit I have restored since 2008. After I have the unit running well enough to pass all my road tests, I rent a local chassis dyno to perform *instrumented* testing. The dynamometer computer display allows me to watch the air / fuel ratio in real time as I fully accelerate and also as I cruise with a road resistance load. I then adjust the stops until I can generate a computer print-out proving proper calibration. A side benefit of this calibration method is that I can usually compensate for a slightly worn gear pump and even some non-stock nozzle sizes.

I'll never again trust GM's "nozzle pressure" method to determine calibration stop settings. It's just not accurate enough to satisfy me.

FI PROBLEMS IN THE IGNITION SYSTEM

When a phone caller asks me to diagnose a problem in his FI unit, I always give him the same initial advice: "First, don't take the unit apart". I say that because many fuel injection problems are actually in the ignition system. There's usually something significant that must be addressed beyond replacing the points, rotor, cap, and condenser with new parts.

Even after fifty years, the distributor cross-shaft gears and mainshaft bushings seldom have much wear **IF** the oil feed tubing has never been disconnected. But many times a past owner will have plugged the oil feed line while he ran an FI distributor with a carburetor. This is a serious mistake. The distributor needs that lubrication even when it's not powering the gear pump. Without the extra oil, the gears can wear out in the center of the teeth. You can tell if the gears are still good by looking at them. If the teeth are the same thickness throughout their length, then they're full strength. A shiny face is okay. However, if they're noticeably thinner in the middle, they should be replaced.

If so equipped, you must make sure the vacuum advance is still working and that it has the correct specs for your model year. The hexagonal '57 - '61 vacuum canister is no longer available new, but Standard Products still sells B22 canisters for '63 distributors and B28 canisters for the '64 - '65 distributors. By the way, these new canisters don't come with a rubber bushing to limit the amount of advance. You have to provide that yourself.

The contact points must have high tension springs to avoid point bounce at engine speeds over 5,000 rpm. I normally install Standard "Blue Streak" ignition parts. Standard has consolidated some part numbers over the years, but the good numbers *used to be* DR2336XP for '57 dual-point distributors, and DR2270XP for the later models. You'll have to cut off the lubrication wick on one set of the DR2270XP points to install them in a '58 - '62 dual-point distributor. I do that with a Dremel tool cut-off wheel.

I've found that some '58 - '65 FI distributors are worn in a way that makes the point dwell change at high rpm. This can be an issue if the dwell drops by more than 5 degrees. This problem could be due to up-and-down movement of the point cam on the mainshaft, or it might happen because of a warped lower housing... I just don't know. The only sure cure is replacing the points with an electronic spark trigger. I normally use the M & H single-wire design because I think it's very durable. The Pertronix set-ups work fine too... well, right up until the time they don't work at all. Take your pick.

Having the right coil and ballast resister is important too. But you shouldn't trust the part number to tell you if the coil is right. For years, one vendor in particular has sold genuine Delco coils with the right numbers but the wrong resistance across the primary windings. Evidently he's been taking old Delco coils from God-Knows-What vehicles and putting new metal skins over the bottom can. Another vendor sells new Delco coils made in China. These overseas coils may work fine with brand new plugs, but they don't provide a strong spark and aren't reliable over time. Check the electrical resistance across the small terminals on top of the coil. Your ohm meter should read 1.5 to 2.1 ohms when the coil is cold. If the resistance is much less than that, you're going to burn your points by passing too much current through them. If it's much more, you're going to have a high speed misfire because of a weak spark. The same test can be used for the ballast resister. It should have 0.3 to 0.6 ohms of resistance when cold.

Here's what I think of reproduction plug wires from Chicago and modern AC spark plugs: they suck. If you have those repro plug wires because they "look correct" with the fake dates, please use them for shows only. Eventually they will cause misfiring at high speeds. The same goes for AC resister type spark plugs. Since AC no longer makes a *non*-resister design, I suggest you use Autolite #295 plugs. Those plugs are equivalent to the old AC 46 heat range.

The mechanical advance curve is determined by the length of the slot in the point cam, the thickness of the bushing on the limit pin, the strength of the springs on top, and the mass of the weights that stretch the springs. I seldom receive a distributor with all those parts working properly. Some of them have usually been exchanged for aftermarket parts that don't fit or work right. In fact, most of the original factory advance springs don't work right either. They allow the mechanical advance to start below idle speed. That gives you an erratic idle speed as the engine hunts for a stable amount of spark advance.

I'm not going to list all the weird distributor aberrations I've come across. It would just depress you. It seems that all Delco fuel injection distributors were owned by Gyro Gearloose at one time, and Gyro "improved" them to the point of not running right. My advice is simply this: make sure your distributor is working properly before you even think about tearing down your fuel injection. You'll probably find at least some of the problems I routinely encounter.

MAKING A '57 FI UNIT RUN RIGHT

The most difficult challenge in the Rochester repair world is getting a 4360, 4520, 4800, 4960, or 7300 FI system to work properly. It's only been in the last few years that I've become confident these units can be made to run right. To get them to that level, you must make several modifications to the original designs, install perfect reproduction parts, and ensure every single component functions flawlessly. You Do-It-Ur-Selfers have now been warned.

You won't have much of a problem getting strong full-throttle acceleration. That's easy to do. It's creating the right air/fuel ratio at low cruising speeds, getting a consistent and smooth idle speed, and starting easily when cold that will have you pulling your hair out with a '57 unit. Here's why.

All '57 FI units were built with sand-cast fuel bowls. These bowls are very prone to "gumming up" with gas deposits, and they are extremely difficult to clean thoroughly. Gas varnish and corrosion sometimes hides between the steel spill valve sleeve and its aluminum casting bore. I haven't found a sure way to remove and re-install this sleeve without scarring the bore. And once the bore is scarred, you darn sure can't drill it oversize without also making some custom spill and fuel valve parts.



This is a typical '57 fuel bowl. Over time, I have learned to hate this design. However, I do like the aluminum used in these castings. You can weld on it all day long, unlike the later fuel bowls made of pot metal.

The spill and fuel valves in sand-cast bowls must have extremely close fits in their bores to work properly. A .001" side clearance is a relatively loose fit, and a .003" clearance is completely unacceptable. However, both the spill and fuel valve pistons must move very freely in their bores. So freely, in fact, that they will fall out from their own weight when placed in the dry sleeve while you're test-fitting them. This means you must carefully polish the sides without removing much material at all. Good luck with that.

The original axle links Rochester installed in the sand-cast bowls were very durable. It's not uncommon to find them still being used fifty years after the units were first assembled. But durable is not everything an axle link in a '57 unit needs to be. It must also be heavily counter-balanced to consistently return the spill valve to the exact position necessary for a proper idle mixture. I've found that Frank Antonicelli's newest reproduction axle link design works better than any GM or other reproduction axle link in a sand-cast fuel meter. Its counterweight is much heavier than that of a Rochester '57 axle link. That's why I think Frank's design works so well.

The main diaphragms GM put in their service "rebuild kits" were very good. Although the last batch of these diaphragms was made in 1975, most emerge in usable condition when found in NOS kits today. But the world is rapidly running out of NOS GM FI rebuild kits. Most of us have to make do with new reproduction diaphragms for our repair work. Here's what you should look for in a repro main diaphragm for a '57 FI unit: a high formed "hump" in the fabric around the magnesium center disc. Some of the modern repro diaphragms have almost no "hump". If you use one of the flat repro diaphragms in your '57 FI unit, you may not have enough sensitivity in your idle mixture screw to get a reliable idle speed. It could also limit the richness of your mixture under full acceleration.

The very first Rochester production design was the 7014360 FI series. These FI systems were such absolute turds that most were replaced by Chevy dealers before the '57 model year was over. They can be salvaged these days, however, if you modify them to function more like the 4520 series design. You must replace the one-piece nozzles with a good set of two-piece nozzles, install a single spider design from a '58 - '62 series, fill the off-idle boost port with epoxy, seal the upper bearing on the distributor mainshaft, install a '58 - '63 enrichment diaphragm spring, and eliminate the Coasting Shut-Off system in the fuel meter. Actually, Chevrolet introduced all of these improvements as running changes in later FI design series.

The second FI series installed during the '57 model year was the 7014520. This system was far from perfect, but it was a great improvement over the 4360 design. It used a single spider, had two-piece nozzles with internal screens, didn't have a CSO system, and came with an upper bearing seal in the distributor. But, it still had an enrichment diaphragm spring that was too short, a poor cold enrichment system, and the unnecessary off-idle boost port.

For the 4520 design, Rochester also modified the 4360 cold enrichment system. They changed it in two ways, both of them making it worse. The cold enrichment housing now had an internal "pull-off" piston that leaned out the A/F ratio on start-up. That's exactly when the fuel mixture needs to be super rich. Also, they sent plenum vacuum to the enrichment diaphragm immediately on cold start-up. That's why a 4520 unit will usually die right after the first start in cold weather. There's no way to keep the enrichment lever on the power stop for the first 30 seconds of running.

There isn't an easy fix for the 4520 "choke" deficiencies. You can eliminate the pull-off piston, but you can't make the enrichment lever stay on the power stop without installing a modified choke housing. And sure enough, that's what Rochester did when they came out with the 7014800 series FI design. The 4800 cold enrichment housing has no pull-off piston and does have a valve keeping vacuum from going to the enrichment diaphragm initially.

But back to the 4520 design flaws... Rochester hadn't yet figured out that the off-idle boost port (in the air meter bore) made low-speed cruise mixtures too rich. In fact, they increased the size of that detrimental boost port when they introduced the 4520 design! The port diameter was double the size used in the 4360 series! You absolutely must close this huge port or you'll have low-speed cruising air / fuel ratios as rich as full acceleration A/F ratios! You WILL have some prematurely fouled spark plugs if you don't plug this boost port.

By the time the 4800 FI series was introduced in mid-1957, Rochester was starting to see the problems caused by the off-idle boost port. They went back to a boost port size smaller than in the 4360 units. However, it still should be plugged to lean out the air / fuel mixtures while cruising at low speeds. As I explained above, Rochester improved the 4520 cold enrichment design for the 4800 series by removing the pull-off piston and installing a valve to keep the enrichment lever on the power stop initially.

The late-'57 7014960 and '59 7017300 series were based on left over 7014800 parts. Therefore the modifications necessary to make them run properly are exactly the same as those for the 4800.

The fine-tuning of 4360 through 4960 units can only be done on a properly running engine. For example, it's impossible to guess the right size for the restriction orifice inside the brass tee above the main diaphragm while on a workbench. You have to set the initial spark timing, run the unit until its fully warm, calibrate it under load, and then test its return-to-idle characteristics. If the engine sometimes dies rather than settle at a 750 rpm idle speed, then you may have too small an orifice in the tee. But maybe not.. it could also be a sticking spill valve, a plenum base vacuum leak, or an excessively lean idle mixture screw adjustment.

After making all these improvements, you'll still have to solve the same problems found in all Rochester FI units: the lack of an anti-siphon electric solenoid, the need for a closely matched set of stock nozzles, the necessity of having an efficient gear pump, etc. However, I'm guessing those ordinary issues will be a lot easier to deal with than solving the special '57 problems I've discussed in this write-up.

<< back to top