Carburetor internal plumbing is a source of mystery, lore, and myth. So let's see if we can sort it out without creating even more confusion.

We'll start at the very beginning.

The saying goes like this: We need 1) **fuel**, and 2) enough **air** to burn it; if we 3) **compress** the dickens out of it and 4) touch it off with a **spark**, the mix will explode. *Zoom*.

Too much or too little of any component will have us stranded in no time.

The first obstacle is that gas is heavy relative to air, so first we need to figure out how to move it against gravity.

To further confound us, we want to maintain this balance whether we're starting from a dead stop or overtaking a competitor at the track.

This is where we breathe a sigh of relief and note that carbureted engines have the benefit of many decades of trial and error development. And even more importantly, the guys who were working it out (really smart guys, I might add) were first and foremost concerned with wringing the full energy potential from the system in a high-performance environment. They did, and still do, spend lavishly on R&D. Racetrack results drive sales, which is where it's all at. Well duh.

The bulk of vintage and classic consumer bikes are therefore merely dumbed-down versions of their track counterparts (thank the EPA largely for that), and of course the trend nowadays is to give the end user the real deal.

But you wouldn't be reading this if you had an R1. You wouldn't need to in the first place.

What *you* have is a 70's or 80's production model bike that may not be running well, and since we deal pretty much exclusively in those makes and models of carburetors...

In my other articles you can read about valves, compression, etc., but I field a lot of questions about jetting so here you go.

First, terminology. If we stick to the same name for a given thing there will be less confusion.

Carburettors have at least two, and in some cases three (or even four), “circuits.”

First is the *low speed/idle* circuit, or simply the 'slow' circuit. It always has at least two jets on it—sometimes three—and governs both idle **and** low speed up to roughly1/4-1/3 throttle. Those are the *slow jet* itself and the *air/fuel mixture screw* or *pilot needle,* which is the term you'll see in Honda manuals.

When we refer to the 'slow' circuit we're including a bunch of stuff: the slow jet itself, the pilot needle, the air cutoff system when present, and certain specific components and passageways that extend from the innermost depths of the carb body all the way to the airbox and to the carb throats. Sounds mysterious, but that's why we're here.

In a three-circuit system there's an intermediary jet on the slow circuit that takes care of mid-range metering. This jet is known as the *primary main* or just 'primary'.

The next circuit is the one that's controlled by the slide needle and it covers demand from 1/3 throttle and up. It is properly known as the *secondary main jet* but you'll see it referred to as needle jet here and there. We use the term secondary main, or simply the 'secondary'.

Pilot, slow, primary, and secondary. What could be simpler.

A moment ago I mentioned mixing the correct amount of air with the fuel before it exits into the carb throat, or 'venturi'. This process is called "emulsification." This is a big word, and awkward off the tongue, so we refer to the two principal parts that facilitate emulsification as the 'needle jet holder ' and, in the three-circuit models, the 'primary main jet nozzle' or simply 'primary nozzle.'

Below is an assortment of needle jet holders from different carb models. I did my best to position them such that you can see all of the side-to-side holes but you have to look carefully at a couple to see them.

Below are various primary nozzles. I snuck a bad one in so you can see firsthand that which constitutes, "reason to toss it into the trash."

You'll notice that the side-to-side holes (AKA “emulsification orifices”) are different in distribution and number.

They meter air into the passing fuel stream and whip it into a froth, which then atomizes as it exits into the carb throat.

The degree to which the fuel is optimally infused with air is the degree to which you'll have fun, or *not* have fun as the case may be.

Obviously if we have more side-holes or if they've been enlarged by chemical erosion (high-pH ultrasound solvents will accomplish this, even Simple Green) we're going to let more air in and thus lean the mix irregularly; conversely, fewer holes, or smaller ones owing to buildup, will enrich randomly. Remember this—the concept surrounding the phenomenon becomes really important later on.

This is one of those areas in the build process where we need to do rather more than have a cursory glance at them, which explains why we go to the trouble to make them look new—else we might miss a defect.

On a side note, there are those instances where we make use of our understanding of how they work to solve a larger problem. We will on certain occasions substitute nozzles and/or holders with more or fewer side holes when we need to adapt to extreme circumstances. It's all about knowing when and how much.

Note that we will from here on distinguish between venturi vacuum and the slightly negative air pressure environment inside the airbox; they perform different, although fully interdependent, functions.

Venturi vacuum is robust enough to suck raw fuel against gravity (think: drinking through a straw), which gross quantity is limited by the sizes of the orifices of the primary and secondary main jet orifices.

Size, distribution, and number of side holes in the holders and nozzles lets a predetermined amount of air into it for optimal mixing. Bingo.

Where does this air come from, you ask?

Pull a slide out and you'll see a kidney-bean shaped plastic cover, beneath which you'll see either one or two small brass jets known as primary and secondary air vent jets. If you look straight down on them you'll see that they're adjacent to their respective main jets. The vent jets lead to cavities around the nozzles and holders. So now you know why there are brass bb's driven seemingly at random into carb bodies. No such thing as an angled mill, you know.

Single-main style carbs ('80-82 CBX, CB900, CB1100) only have one vent jet.

Some refer to them as “lift vent” jets, as though they aid in moving the slides but this is not so. They're open to the airbox interior via a passageway *under* the little cover and thus isolated from the slides.

So while the main jets are themselves submerged in fuel and thus under venturi vacuum, the side holes in the holders and nozzles are open to the airbox.

Venturi vacuum overpowers the airbox such that both fuel and air are drawn up together in correct proportion—or so we hope.

Now to the pilot needle. This one's a little more complicated. They don't call it the air/fuel mixture screw for nothing but how it does this is nothing short of genius.

Without getting bogged down in minutiae let's stipulate that Honda carbs always have the pilot needle on the engine side of the throttle plate. (Other carb types locate it on the airbox side but that's immaterial to the present.)

When you close throttle you're protecting the airbox side of the carb from vacuum. So on the airbox side it plunges to near-zero but on on the engine side of the plate it spikes up.

So, we position the pilot such that it's always under vacuum to let fuel through for idle.

The magic is that adjusting the pilot in or out not only allows more or less flow through its own little self but through the entire slow speed circuit. (The air cutoff is also connected to the slow circuit but it'll only muddy things if we get into it now).

Some believe that pilot needles control air but this is wrong. When you, for example, *open* the pilot you're *decreasing impedance to fuel flow* and thus enriching. Conversely, closing the pilot increases impedance and leans the mix. This sounds counter-intuitive but not when you consider that the availability of air is fixed and can't be readily changed unless we alter the physical characteristics of airbox itself—or that of certain internal (impossible to reach) components.

The only parameter over which we can gain *variable* control is the amount of fuel available, which flow is itself held in precarious balance in a tug of war between venturi vacuum and gravity. So all we have to do is figure out where's the best place to put a user-adjustable metering device to alter that balance and thereby alter flow. Brilliant in its simplicity. By now it seems so...obvious. Hopefully anyway.

The reason this is so important is that, while you may not be aware of this, during around-town riding you spend the vast majority of your time on the slow circuit. The needle rises under acceleration (or on the highway) but if you're putting along in 3rd gear at 25 MPH the slide is all the way down.

In fact, you can remove the caps, springs, and slides from a properly tuned carburettor and it'll start, idle, and rev—to a certain point—flawlessly. The key to this being 'properly tuned.'

Needle jets are *mostly* on their own circuit. I say this because in a three-circuit carb (DOHC CB750, '79 CBX, GL1000, GL1100 and others), needle jet holders' air vents are nestled alongside the slow jet air vents so they share a common air source and therefore there's a small amount of feedback between one another.

This next matters a whole lot: *The vent air jet sizes are inversely reciprocal to their respective main jet companions.* Confused? Let's say that you have a three-circuit carb with size 65 primaries and size 98 secondaries. (This just happens to apply to DOHC CB750 and '79 CBX. How convenient is that.)

If you were to measure the orifices of the vent jets you'd find that the one connected to the primary is size 98 and the one for the secondary is size 65. Why the size reverse? It's because there are more passageways on the slow/primary circuit so it needs more air. And remember, we can control flow through it with the pilot in case things go out of whack.

The secondary main is (more or less) on its own so it wants a smaller one.

Now to the ever-mysterious air cutoff.

For this one we need only concern ourselves with the low speed/idle/pilot circuit. The air cutoff is connected to it, but is plumbed in a clever way which we'll get to later. The important thing to concentrate on for now is that it too is ported to the engine side of the throttle plate like the pilot. It too is subject to vacuum spikes when the throttle closes whilst the engine is at high rpm.

With the throttles closed the only place fuel can come from is through the pilot, and it won't supply nearly enough to satisfy high RPM demand. Consequently the mix leans out drastically, at which point you get that characteristic popping through the exhaust, which is itself the result of a phenomenon known as "preignition"—where a too-lean fuel/air mix ignites spontaneously under compression. Pre-ignition by the way is unhealthy to valve train components.

The solution? Easy. Add a little more fuel during this crisis phase to temporarily enrich. But how?

What we need is something that facilitates the introduction of more fuel, but only at those times where preignition is a problem, ie under moderate to hard deceleration.

We know from our understanding of how nozzles perform, in particular *clogged* ones, that *decreasing* available air *richens* the mix.

We also know that vacuum on the engine side of the throttle plate spikes up dramatically when the plate is closed abruptly.

I'd wager that by now you know exactly where this is going. In fact if I've explained this properly you're already there: The air cutoff does precisely what its name implies—temporarily cuts air to the slow circuit and dumps a little more fuel to the pilot.

From there it's merely a question of balance. The spring needs to exert just enough force to hold the piston in the neutral position (unrestricted) until vacuum spikes upward enough to overcome it, at which time the piston moves to block a special passage which also supplies air to the slow circuit. When vacuum tapers off the spring returns the piston to neutral.

Here's where the plumbing is unique. The air cutoff has its own vent jet, which is also under under the rim of the slide. However it's on the opposite side of the slide bore from the main jet vents; and not only that but rather than being under an isolating cover it's open to the ambient pressure environment of the slide bore itself.

This means that the air cutoff can disrupt air flow to the slow circuit independently of the fuel jet vents.

So in truth the slow circuit is supplied with 50% of its air from the airbox and 50% via the air cutoff. When we take away the air cutoff portion we're *just* rich enough to suppress preignition.

You think this is by accident? No. Someone tortured carburetors until they coughed up their secrets and if they hadn't we'd still be coasting downhill on sleds.

Another factoid: On the DOHC inline fours every carb body has its own air cutoff, but the CBX uses just one for the whole rack. If you have them upended on the bench with all the brass removed and you use a syringe to inject a little gasoline in the #6 body's pilot bore and follow it with a blast of concentrated compressed air, you'll have mist coming out of the primary air vent jet on the #1 body!

This serves to underscore the importance of having the slow/pilot circuit in perfect order where it concerns the CBX. Not that it's unimportant on the inline fours (perish the thought!) but for the CBX, the fact that all six bodies "communicate" with each other renders it such that modifying—or failing to properly sort—a given parameter in one affects them all.

What I'm hoping you'll take away from this is that a certain amount of flexibility comes with the desig. But you can only push so far.

Fiddling around with this or that without accounting for what will happen elsewhere can get you into trouble if you don't plan accordingly.