Attack of the Vapors

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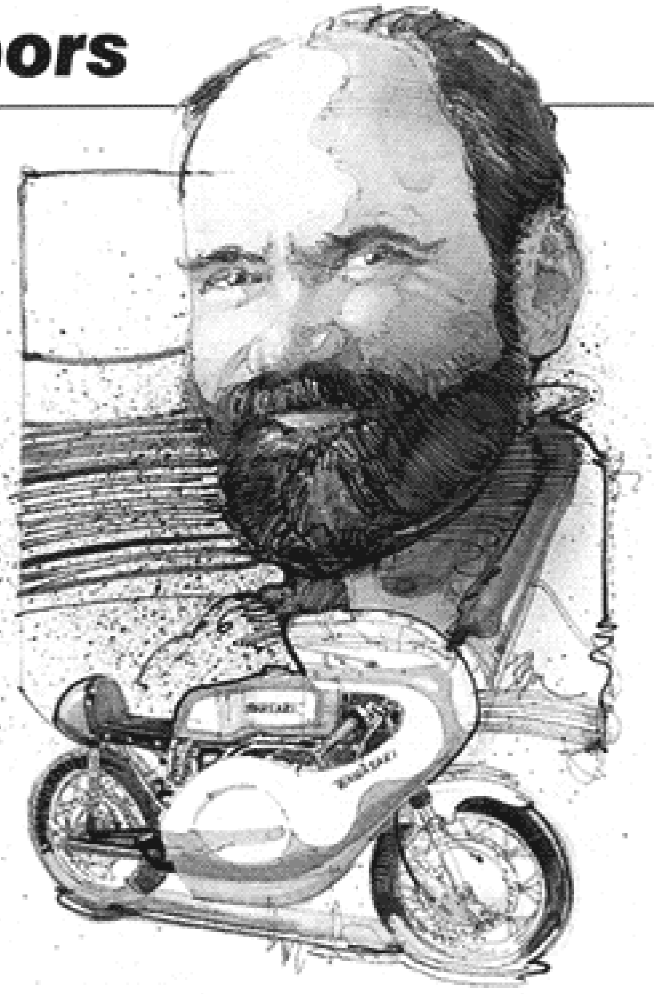
MORE THAN A HUNDRED YEARS AGO, when it was first understood that useful engines could be made to run by burning gasoline vapor right in their cylinders, forming the vapor was one of many problems. The first carburetors operated in a very obvious way; they were either large, flat pans of gasoline, over which the intake air flowed on its way to the engine, or they took the form of great big wicks inside the intake pipe, kept perpetually wet with fuel.

This was effective because the resulting vapor was completely evaporated fuel–no fuel droplets reached the engine to suffer possible incomplete combustion. But it was also difficult to control; the trick was to adjust the air control to match the rate of fuel evaporation, keeping the fuel/air mixture within the combustible range. Throttle response? There wasn't any–you were lucky to get your engine started, and thereafter operated it at near-constant speed with careful adjustments to mixture.

On cold days, fuel evaporates more slowly, and early fuels varied in volatility. To assist evaporation, therefore, an exhaust pipe might be routed through the evaporator to speed the process. Today, the notion of running a hot exhaust pipe through a fuel tank seems a bit rugged, but it worked.

Another problem with evaporators was that they tended to become stills; as intake air flowed over the fuel or wick, it naturally carried away the most volatile elements of the fuel first, with the result that what remained became less and less volatile. Eventually, the engine might not start at all on the heavy residue, which would have to be replaced with fresh fuel.

These problems suggested the idea of a spray carburetor, which would use all the fuel without problems of selective evaporation. It would simply spray liquid fuel into the intake pipe. Bernoulli's Principle was applied here, which observes that the pressure of moving air is less than that of still air. Making part of the intake tract as a venturi would locally speed up the airflow, creating a strong vacuum which could be used to draw up fuel from a nearby reservoir. The fuel would discharge, or spray, into the high-speed venturi airflow.



It worked–sort of. As before, the problem was to keep fuel and air flowing to the engine in correct proportion. It wasn't hard to get a good adjustment for constant speed, but vehicles now needed more convenient speed control. On these early carburetors, when you opened the air throttle to go faster, you had to simultaneously open a fuel throttle by a proportional amount, or the engine would go lean and die. It was a busy process.

The next step was the "automatic carburetor." It linked air and fuel controls together into a device that would automatically maintain a combustible mixture over some range of engine speed and load. The Indian Motocycle Company was a pioneer in this work. Many clever devices were made to accomplish this. Some were as simple as a mechanical linkage that caused a threaded fuel needle valve to unscrew as the throttle was opened. Others used multiple fuel jets that came into operation in series as a moving throttle plate exposed them.

Motorcycles settled on the system of a cable-controlled sliding air throttle, carrying a tapered fuel-metering needle that controls the flow of fuel from a tube–the needle jet. Screwed into the bottom of this tube is the main jet. The tapered needle takes care of fuel metering as the throttle is opened, but once open, such a carburetor gets richer and richer as the engine revs up. This is because air is elastic, but fuel is not. The faster air is pulled through the carburetor's venturi, the lower its density becomes, but the fuel density remains constant. The result is enrichment. To prevent this, air is bled into the needle jet through tiny holes, from an air jet. If the air jet and main jet are correctly proportioned, the flow of bleed, or correction air into the fuel, exactly compensates (well, kinda) for the natural enriching tendency.

There are other benefits to this so-called air-correction system. First, a column of frothy fuel with air bubbles in it is lighter than fuel by itself. This makes carburetion more responsive to subtle changes in the engine's fuel demand. Second, the presence of all those tiny air bubbles in the fuel helps break up the fuel stream when it sprays into the intake air stream.

Over many years, countless engineers and tuners have struggled to master the science and quirks of the carburetor. But nothing is ever enough for us humans. Carburetors, after all, are stupid devices that know not what they do. We are now replacing them with electronic fuel injection, which promises to do exactly what we tell it to do. Oughta be good, right? The trouble is that, like computers, fuel injection *does* do exactly what we tell it to. Where the overlapping systems of the carburetor, and its dribbling, imperfect nature conspire to smear out and soften any problem, fuel injection does only what it is told. It is like an obedient but stupid assistant who lacks all common sense. Because of this, complex software must be written to tell the injectors how to act like carburetors–an exacting business.

What's worse, injection doesn't break up fuel even as well as most carburetors do. In carburetors, the fuel spray hits very high-speed venturi airflow, which effectively atomizes it. With injection, the fuel is sprayed into a larger cross-section, where the air is moving more slowly. Impact with high-speed airflow is the first key to fuel evaporation. The second is time. At high rpm, when the time of flight of fuel from injector to cylinder is very short, fuel injected down near the intake valves may not have enough time to evaporate. The result is leanness, as larger fuel droplets pass through the engine unevaporated. This is why high-rpm engines in F-1 or Superbike racing extend the fuel's evaporation time by locating a second injector farther upstream in each intake tract–possibly so far up that it hovers above the intake bellmouth. Novelty isn't identical with progress. ◘