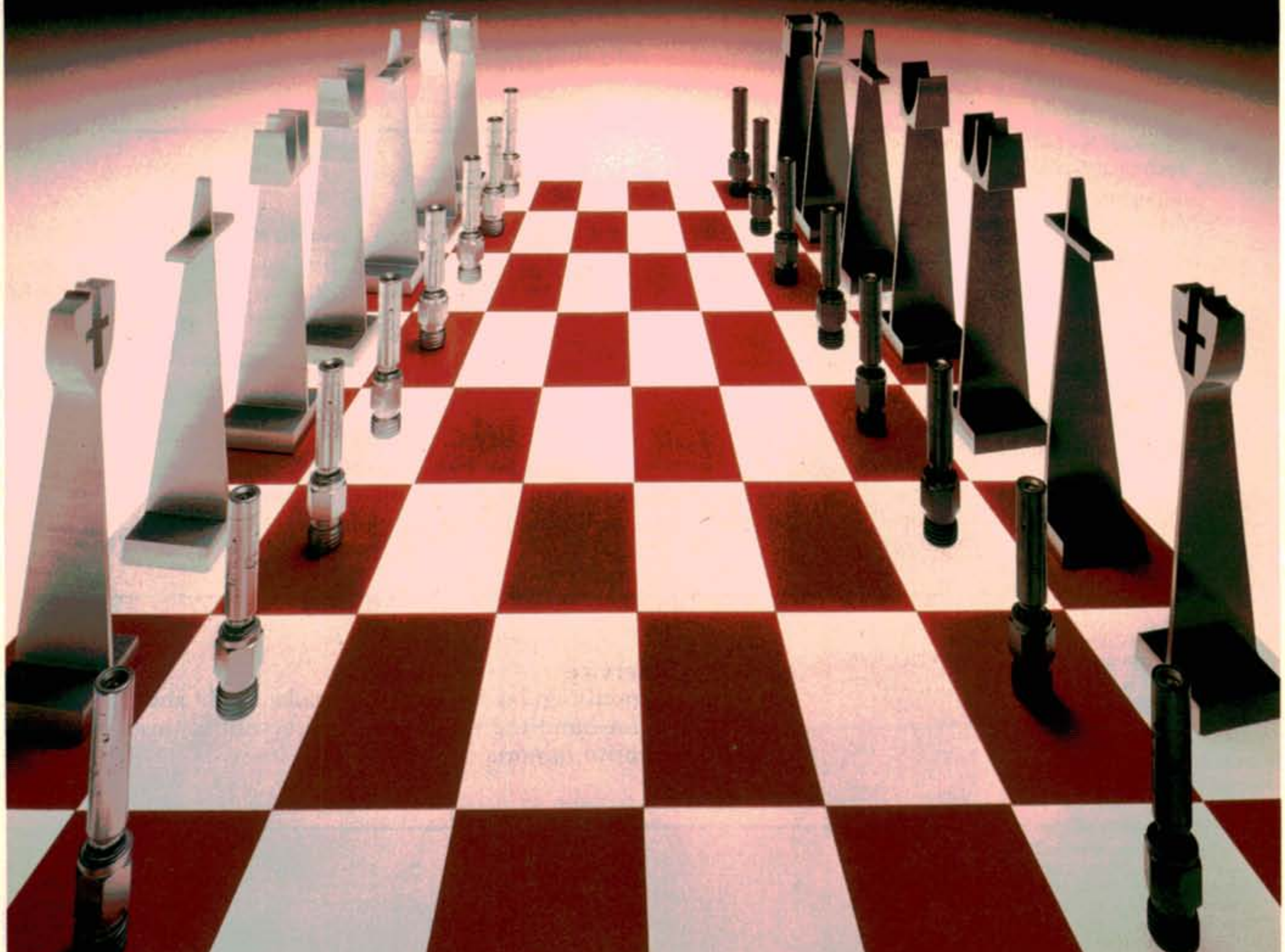
KE-Jetronic Strategies



You don't have to be a chess player to know that chess is a game of strategy and feedback, a game of war. The chess player commands an army of players. He is constantly assessing that army's position—constantly evaluating what each soldier's actions can do to his strategy.

Teutonic engineers realized that certain unfavorable conditions existed on the field of battle for the original K and K-Lambda systems. They looked at the checks and checkmates caused by certain extremes of temperature and added some new players to the regiment.

These new players were able to adapt to battlefield conditions and keep the player, the ECU Commander-in-Chief, better informed about the battle plan. As a result, they have been amazingly successful in creating a reliable fuel system with greatly improved driveability.

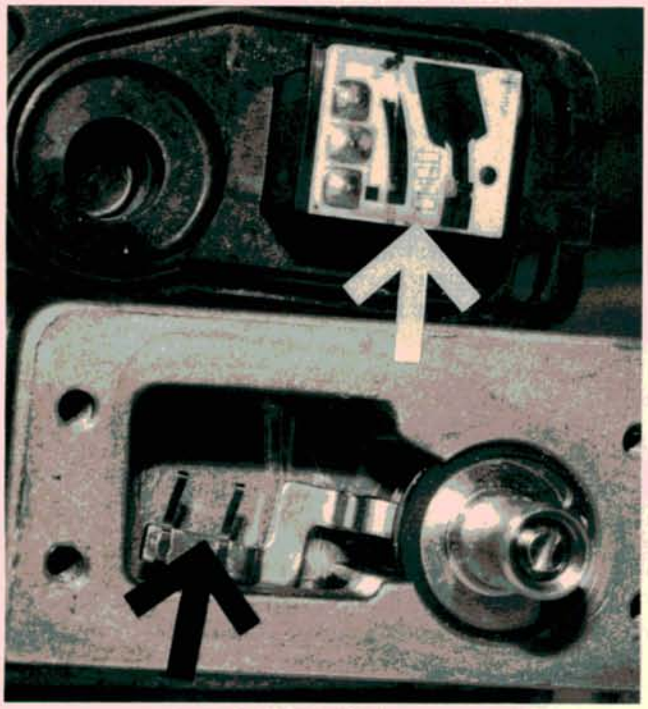
As with all the versions of this wonderful system, the basic fuel metering is hydraulic. Even if all the electrical spies at the front lines go south for the winter, the car will still run. It won't run well, but it will get the owner home. The only thing really necessary is the fuel pressure created by the king of the board, the fuel pump. (Actually there are two pumps to contend with, but we'll look at that later.)

Swept from the board are two of the players that caused some problems in the past, namely:

• The warm up regulator (AKA the control pressure regulator);

• The frequency valve;
• Also gone is all the plumbing connecting these items to the fuel system.

While some manufacturers like Volvo have left the K-Jetronic tournament, Volkswagen and Mercedes still find KE an important part of their strategy.

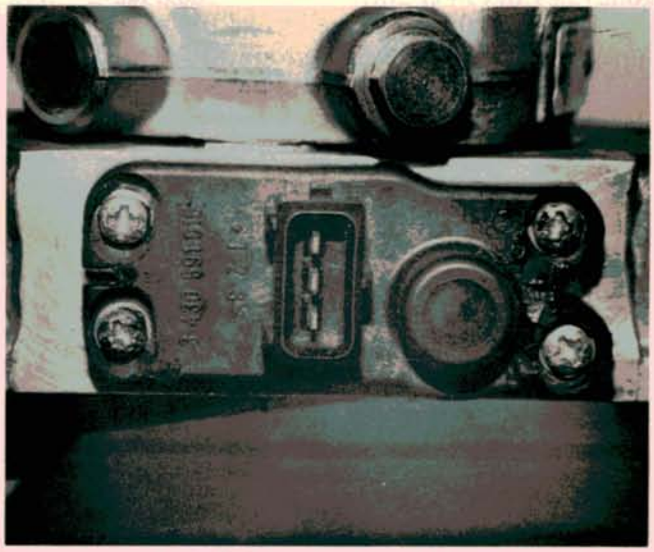


This photo shows the wipers (black arrow) and the sensor plate potentiometer contacts (white arrow). The wiper arm is attached to the sensor plate pivot, but should be insulated from it.

The Commander-in-Chief

Now our regiment is commanded by a single computer. This ECU Commander controls idle speed and fuel mixture, compensates for changes in altitude, limits maximum engine speed, controls fuel shut-off during deceleration, and in some cases, controls the cold start valve. It makes moves to provide enrichment in a number of cases. These extra moves are the key to this new system being so driveable.

Now, in addition to the moves it could make before, the ECU Commander also controls these functions:
• cranking enrichment;
• starting enrichment;
• warm up enrichment;
• deceleration fuel cut off;
• acceleration enrichment; and,
• full load enrichment.



The sensor plate potentiometer is held in place by four screws in slotted holes. Loosening the screws and rotating the plastic housing allows for the base adjustment of the potentiometer.

The Commander's Spies—The Sensors

In order for the ECU Commander to move his men wisely, he needs sensors, or spies, to provide him with information. In earlier issues, we discussed the barking dog oxygen sensor. This spy is still present in the KE system and reports to the Commander without any questions from him. But the rest of the spies need constant prodding from the commander or they won't make a sound.

This ECU Commander sends out voltage signals to each spy at the front lines—beneath the hood where the action can get really hot. Each spy replies by sending back a coded version of that signal. Here's a list of those spies and the signals they send back to the ECU Commander.

The Coolant Temperature Sensor (CTS). This spy is threaded into the coolant outlet so it can report the temperature of the engine—when it's cold—and as it warms up. The ECU Commander uses this information to richen the fuel mixture when the engine is cold to improve driveability. In a way, this new soldier replaces the old warm up regulator. The CTS is a negative temperature coefficient thermistor. That means that the HOTTER it gets, the LESS resistance it has. The COLDER it gets, the MORE resistance it has.

At the very coldest extreme, the CTS has 20,000 ohms of resistance. At the hottest extreme, it has less than 100 ohms of resistance.

The ECU Commander questions the CTS by sending it a 5-volt signal. When it's extremely cold at the front lines in the engine, the CTS resistance is very HIGH. This high resistance blocks the move of the voltage signal as it travels to ground. The ECU reads the same 5 volts it sent originally and knows the engine is cold. It richens the mixture, with results similar to that of a carburetor choke.

This new system has an o-ring at the base of the control plunger. When you lift the air sensor plate as shown, there should be a small amount of free play before you feel the arm contact the plunger.

As the engine warms, the resistance in the CTS gradually decreases. More and more of the 5-volt signal travels to ground. The ECU commander receives this message from his spy and gradually leans the mixture for warm operation.

The Airflow Position Sensor (APS). This electrical spy might also be called the sensor plate potentiometer. This spy is similar to the throttle position sensor used on many late model cars. Our ECU Commander wants to know where the sensor plate is.

Two metal wipers are attached to an arm on the pivot rod for the sensor plate. These wipers move across a carbon film resistor that changes about 4000 ohms from rest to full deflection. The ECU Commander sends an 8-volt signal to the sensor spy on one wire. The APS has a return line to the ECU and calls back to inform the ECU about the sensor plate's position.

As the sensor plate moves through its 18 degrees of total movement, the APS resists less and less of the 8-volt reference signal. When the key is on, and the engine is off, the return signal voltage will be close to 0 volts. As the airflow sensor is drawn upward by a running engine, the voltage signal sent by the APS spy will increase. With the sensor at its highest position, the voltage signal will be about 7 volts.

The ECU Commander uses this information to determine whether or not acceleration enrichment is needed during warm up. The position of the APS is adjustable.

The Throttle Position Switches (TPS): Idle and Wide-Open Throttle. The idle TPS is located on the throttle housing in such a way that it opens and closes *before* the throttle butterfly does. It reports to the ECU Commander that changes in the throttle position are ABOUT TO HAPPEN. This allows the ECU Commander to anticipate changes in throttle opening. This is how the ECU knows when the deceleration fuel shut off mode is needed.

The ECU Commander sends a 12-volt signal on one wire to the switch and gets a return message of 12 volts, or no message at all, depending on throttle position. At idle, the ECU gets a 12-volt signal. As the throttle just begins to open, the return signal drops to 0 volts.

The Wide-Open-Throttle (WOT) TPS. This throttle position switch tells the ECU that full throttle enrichment is needed. The WOT spy does this by closing the switch and sending a 12-volt signal back to ECU headquarters.

The RPM Signal. This isn't exactly a new spy. But the message sent by the RPM spy is very essential. The engine won't run without it. The ECU Commander uses the RPM signal along with the TPS signal to determine deceleration fuel shut off. This signal is also used to keep the fuel pump running. Without it, the Commander thinks the car has been crashed and shuts off for safety. This spy sends his message from the distributor to terminal 25 of the ECU.

The Ignition-Start Signal. This spy informs the ECU that the engine is being cranked. He sends his signal from the starter crank circuit to terminal 24 of the ECU. The ECU Commander then requests cranking enrichment.

Barometric Sensor (BARO). Some models are equipped with altitude compensation. This pressure sensitive spy gets a little light-headed at higher altitudes and complains to the ECU Commander. The ECU sends out an 8-volt reference voltage, but as the spy gets dizzy at higher altitudes he returns a weaker signal. This signal is received at terminal number 11 of the ECU.

Playing the Game

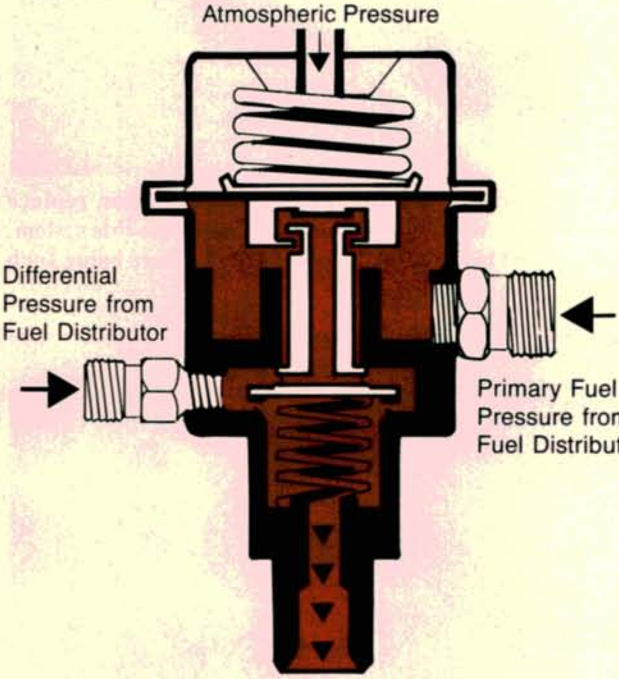
Since the basic hydraulic principles of the old K-Jetronic system are still in place, some design features of KE are very similar to the old system. Let's look at how some things stay the same, and how some very important things have changed.

The Fuel Pump. In order to compensate for some fuel related problems that caused hassles in the old system, two fuel pumps are now used. System pressure has been raised to 5.4 bar (78.3 PSI). This higher pressure helps keep fuels with highly volatile additives from percolating at higher temperatures. There is a transfer pump in the tank that feeds an externally mounted pressure pump. A separate reservoir in the tank keeps a constant supply of fuel available to the pump, even when the vehicle does some hard cornering. The pump is still fitted with a residual check valve as before.

Diaphragm Pressure Regulator. Gone is the primary pressure regulator that was located in the fuel distributor. Fuel pressure is now controlled by a semi-conventional pressure regulator located next to the mixture control unit. It operates in the same manner as a typical EFI pressure regulator, with one significant difference—it has an additional inlet.

This extra plumbing connects the fuel pressure regulator to the side of the fuel distributor. This allows a "spill port" to leak fuel from the lower chamber back into the regulator. This leak is calibrated and constant.

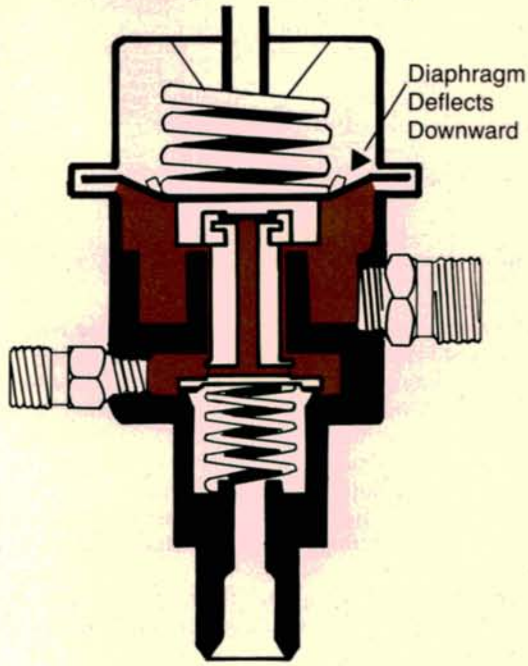
Pressure Regulator
With Engine Running



With the engine running, system pressure is regulated as follows:

- **Fuel pressure from the fuel distributor enters the inlet port.**
- **It works against the spring loaded diaphragm at the top of our illustration.**
- **As fuel pressure moves the diaphragm, the inlet valve opens, and the sealing plate at the return orifice to the fuel tank also opens. This allows the excess fuel to return to the fuel tank. Fuel from the "spill port" in the fuel distributor also returns to the tank at this time.**

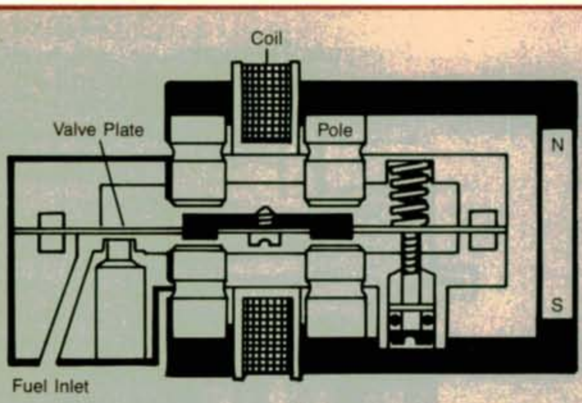
Pressure Regulator
With Engine Not Running



When the engine is shut off, the fuel pump shuts off and fuel pressure on the diaphragm decreases. The large spring above the diaphragm now overrides the reduced fuel pressure. The sealing plate in the pressure regulator slams shut and closes the return line to the tank. This closes the escape to the tank from either source; the spill port or the fuel distributor. In this mode, the pressure regulator acts as a big one-way valve.

The Fuel Distributor. The fuel distributor used in the KE system is a really different soldier from the old distributor used in the K and K-Lambda systems. There is no more control pressure. There is no frequency valve. Other changes include:

- The pressure relief valve is gone.
- The pressure regulating springs are now in the LOWER chamber.
- The size of the upper chambers has been reduced.
- The control plunger in the fuel distributor now seals against an o-ring when the engine is off and the sensor flap is all the way down. As a result, there is now an air gap between the sensor plate arm and the plunger with the engine off.
- System pressure is always present in the upper chamber. We no longer have control pressure changing above the control plunger as the vehicle warms up.
- Since we now have constant system pressure in the UPPER chambers, we have to use a differential pressure regulator DPR (or electro-hydraulic actuator) to control the pressure in the LOWER chambers.



The differential pressure regulator uses two electromagnets to play tug of war with a thin plate valve that deflects to control fuel pressure between the upper and lower chambers of the fuel distributor.

Milliamp current from the ECU Commander varies in strength depending on whether or not he wants to richen or lean the fuel mixture. By increasing the current supplied, he can change the strength of the magnets. The stronger the magnetism, the more the plate deflects.

By reversing the current flow, the ECU can move the plate in the opposite direction, simply by reversing magnet strength.

Even if the current to the regulator stops altogether, there is still enough system pressure to deflect the plate about 0.4 bar. The force of the pressure regulating springs in the lower chambers will eat up about half that pressure, but about 0.2 bar pressure differential will remain. This mechanical differential will allow the engine to keep running in "limp home" mode, although the car will struggle with the lean mixture, and may not restart when cold.

A Differential Pressure What?

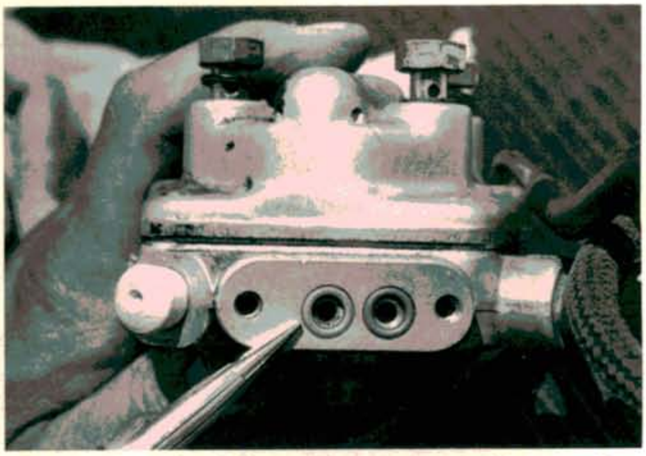
The Differential Pressure Regulator is the soldier who executes the ECU Commander's orders on the field of battle. This soldier is also known as the Electro-hydraulic Pressure Actuator. We like the first term a little better, however, since a pressure differential is exactly what the actuator has to make for the system to run.

Up to this point, the spies have provided the ECU Commander with intellegence and counter intelligence. Now, back at headquarters, decisions are made based on this information and orders are sent to this one new player on the board who can execute them.

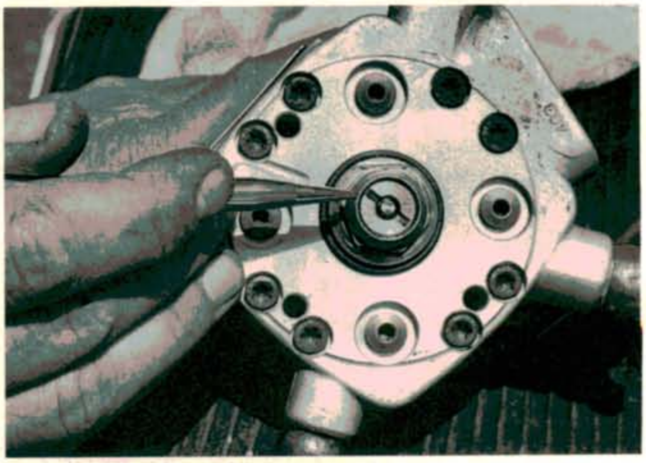
Messages are sent to the differential pressure regulator in the form of varying current. Since the regulator contains an electromagnetic valve, the amount of fuel allowed to pass through the differential regulator is as easily controlled as twisting a stereo volume knob.

The differential pressure regulator bolts to the side of the fuel distributor and is sealed to it with two o-rings. One o-ring seals a passage from the upper chamber into the regulator. The other o-ring seals the regulator to the lower passage.

Without getting into a lot of complex hydraulic theory, let's just say that the regulator is connected between the upper and lower chambers. Injector fuel delivery is changed as the regulator controls the amount of pressure passing from the UPPER to the LOWER chamber.



If you replace the differential pressure regulator, replace these seals as well. There's a lot of pressure in this system, and it's hard to imagine the possibility of there being such a thing as a "small leak."



The slotted collar allows you to set the sensor plate lever basic adjustment. This setting establishes the rest clearance between the sensor plate roller and the control plunger.

The more the differential regular opens up, the more pressure is allowed to build up in the lower chamber. And since we've already noted that UPPER chamber pressure is held constant, the change in LOWER chamber pressure changes delivery to the injector ports.

When the pressure regulator opens all the way, the lower chambers have enough pressure to move the diaphragms up against the fuel outlet tubes to the injectors and shut the fuel COMPLETELY OFF. That's why the spring was moved to the lower chamber. It helps push against the diaphragm to shut it off. This is how the ECU Commander shuts off the fuel during closed throttle deceleration above a certain RPM.

The opposite happens when the differential regulator restricts the flow of fuel from the upper to lower chambers. Reduced pressure in the lower chamber allows the greater pressure in the upper chamber to push the diaphragms in the fuel distributor downward. This opens the injector passages and the system goes RICH. (For the theorists in the crowd, who want a more detailed explanation of the differential pressure regulator, see the sidebar.)

Amp Power

In the K-Jetronic Lambda system, the Commander controlled the mixture by changing the duty cycle. Now the fuel mixture is controlled by changing the strength AND direction of the current passing through the differential pressure regulator windings.

The current can go from as much as 120 milliamps in one direction to -60 milliamps in the other. The more + the current goes, the less fuel the differential regulator allows to pass from the upper to lower chambers. This greater differential in pressure bows the diaphragms downward away from the outlet ports. Result? Fat, rich mixture. The opposite works the same way.

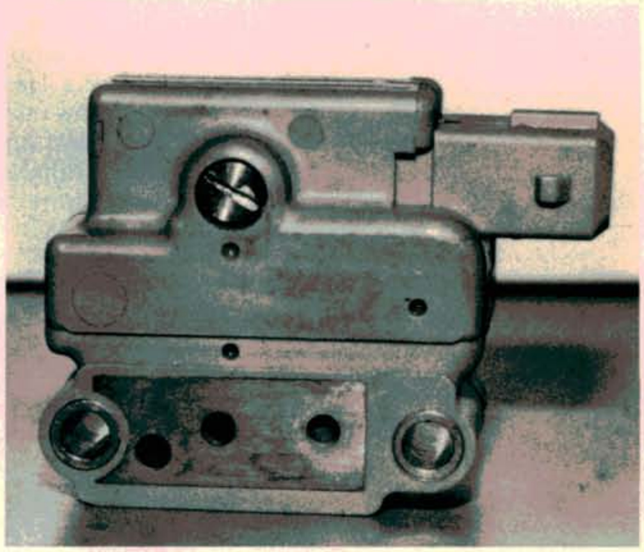
Higher Current +milliamps mA	=	Richer Mixtures	=	Larger Differential Pressure
Lower Current -milliamps mA	=	Leaner Mixtures	=	Smaller Differential Pressure

Counter Intelligence

To tap into the system, you'll need Thexton tool #391 (or a similar tool, either purchased or made.) Unplug the connector at the differential pressure regulator and plug the harness between the regulator and the car harness. Modify the harness by chopping into one of the two wires between the male and female connectors. Connect your millameter in series with the chopped wire ends.

This "phone tap" allows us to do a little spying of our own. Now we're listening in on the conversation between the ECU Commander and the differential pressure regulator. We can eavesdrop on the milliamp coded messages. (When reading your meter, remember that -mA readings with the engine running probably mean your meter leads are reversed.)

Never let the leads short together or touch ground or you may blow the ECU Commander's mind!



The differential pressure regulator is small enough to hold in your hand, but big enough to carry out the ECU Commander's orders across a wide range of driving conditions.

Firing Range

The normal range of operation in open loop is a fixed value of 7 to 10mA. Closed loop operation is a varying range between 4 to 16mA with fluctuations of about 3mA. The determination of a car's ability to achieve closed loop operation is of the utmost importance when troubleshooting problems.

We've Only Just Begun

There's a lot to know about this system. We'll let you soak this much up for now. But we're hardly finished looking at the system. We'll continue our look at KE with further explanations of the system in a sequel to this introductory article.

—By Dré Brungardt