20 to 40°F without any aid. Lower temperatures will require a cold-start device unless you are using E-85 or alcohol with ether added to make it more volatile in cold weather. The winter blend of E-85 actually contains as little as 70% alcohol in cold Midwestern states, the rest being made up of gasoline or other petroleum volatiles. Since gasoline and/or natural gas condensates have a very low flashpoint, they will evaporate and explode when sparked at temperatures of 45°F below zero. When added to alcohol, these substances permit the engine to get enough vaporized fuel to start in most weather conditions without the use of a cold-start device.

Many of these substances are considered toxic waste by the oil or natural gas companies, and they are only too glad to dump them into the fuel during the winter. Sometimes, however, the oil companies go a bit overboard. In 2004, in South Dakota, they were disposing of so many volatiles in the E-85 blends that widespread vapor-locking was happening throughout the state *in the winter*!

If you don't care to use petroleum additives full time in your fuel just to provide for cold-starting help (and who could blame you), there are several external methods for cold-starting an engine.

## ADDING ETHER OR OTHER FUELS

Truckers have used pure diethyl ether to start diesel engines for years, and their system will work on alcohol-fueled engines, as well. The ether comes in a metal bottle, similar to a small propane bottle, that can be screwed into an electric metering or solenoid valve wired to the vehicle key, or to a switch mounted on the dashboard.

In cold weather, you simply push a button that triggers the solenoid valve to give the engine a measured amount of ether. Be precise with the amount of ether, as too much can cause engine damage. Two cubic centimeters—about a thimbleful—seems right for four- and six-cylinder engines. Four cubic centimeters is plenty for eight-cylinder engines.

When ether leaves the metal bottle, it travels to your engine through a ⅛-inch tube connected to the manifold. The instructions in commercial kits recommend that you tap a hole into your manifold and thread in the injector so that the ether can be atomized directly into the manifold. The atomized ether is then sucked into the engine by vacuum. (If you do have to drill and tap a hole, remember to do this with the manifold off the engine, so that drill shavings can't get sucked into the engine.)

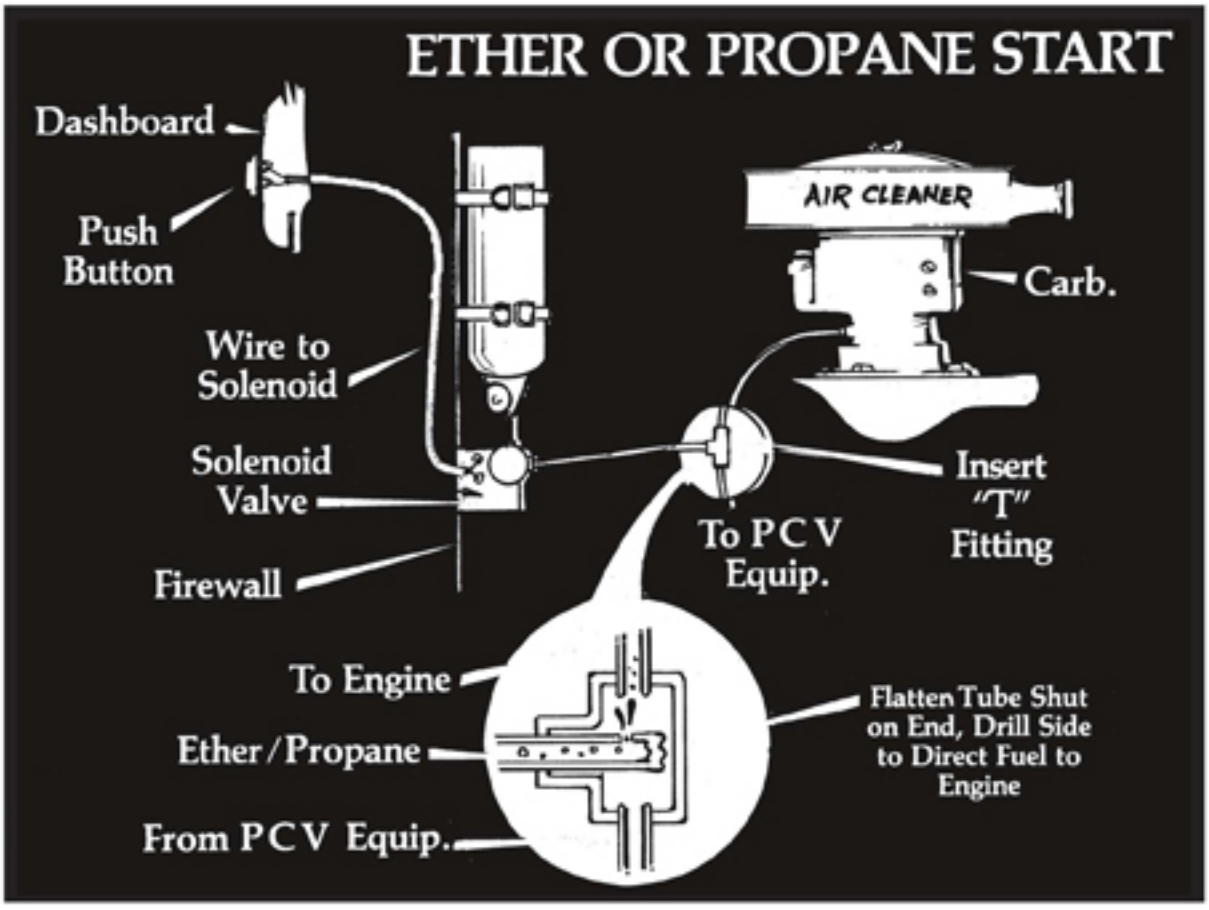


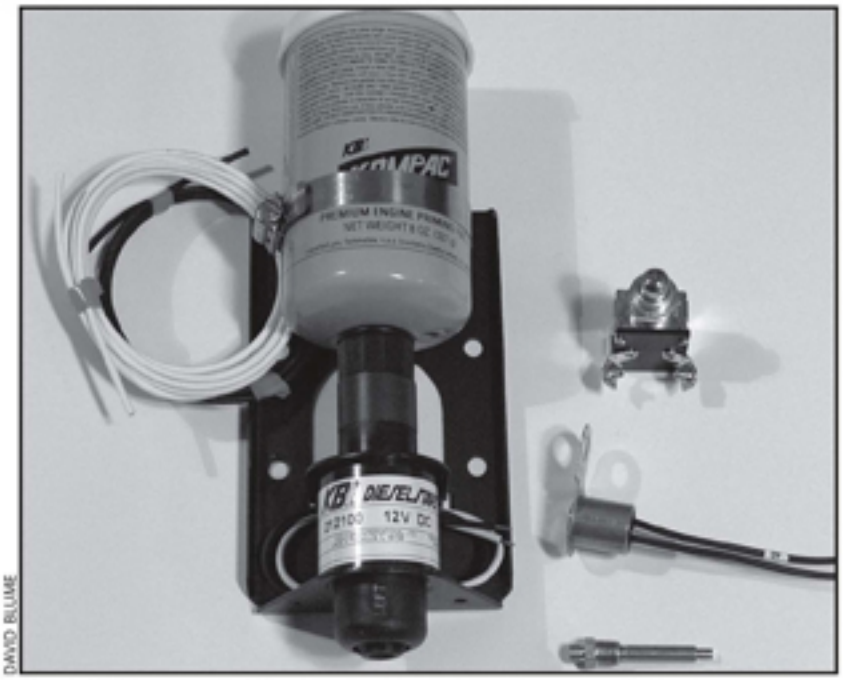

***Fig. 17-2 Ether or propane cold-start.*** *In either case, a small bottle of compressed starting fuel is mounted on the firewall. The electric solenoid valve opens when you turn your key to start, and the thermostatic switch senses the temperature of the engine is low. You get a shot of volatile starting fuel, and that starts the engine. Although this diagram shows fuel entering through a constant vacuum fitting on the carburetor, any constant vacuum fitting on the manifold will serve in fuel-injected systems.*

An easier way to get the ether to the manifold is to insert a T directly into a vacuum line. Your positive crankcase ventilation (PCV) line is an excellent line to tap for this purpose. This line is designed to continuously suck oil vapors from your valve cover or other crankcase location and shoot it back into your engine, where it's supposed to re-burn. (In much older engines, these oily vapors used to be vented to the air.)

Use hose barbs on the through line of the T, with a compression fitting on the T's branch. Insert your injector—a piece of tubing with one closed end and a tiny hole drilled in the other end—and seal it into the branch by tightening the compression fitting. Place the T as close to the carburetor as possible.

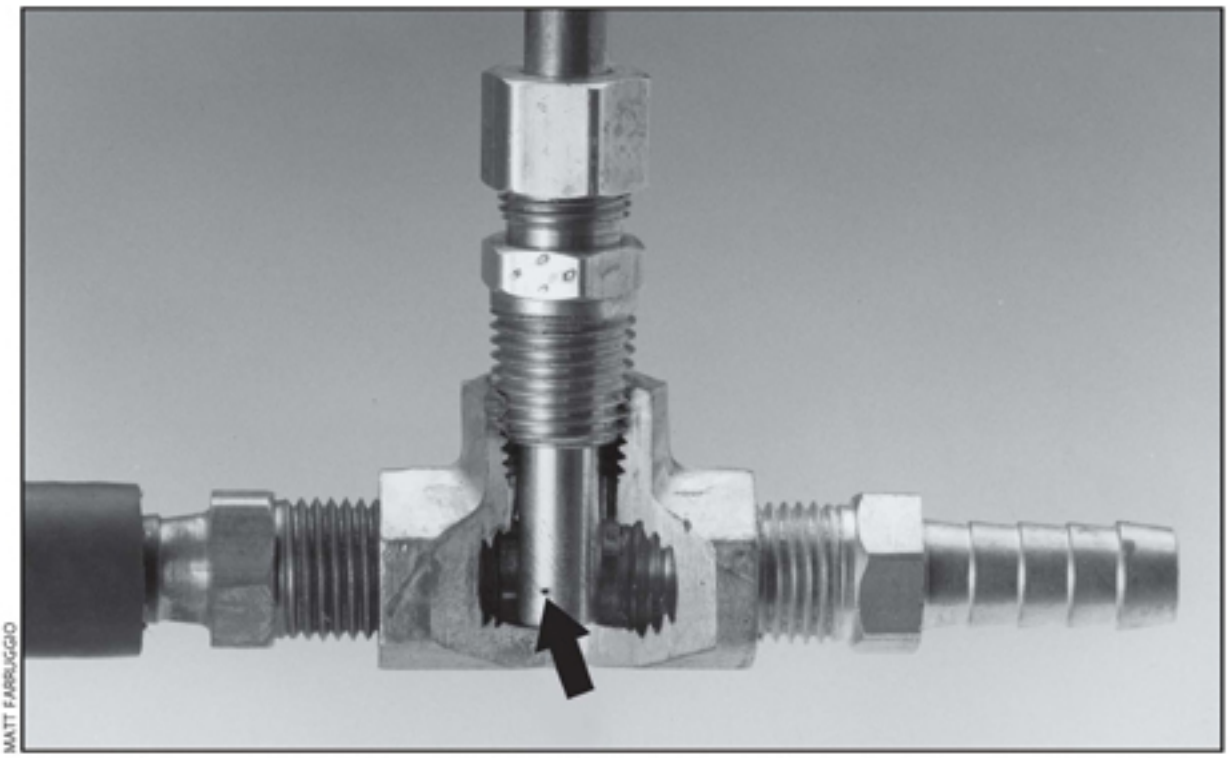
The kits come with a sophisticated atomizer that spreads the dose of ether over several seconds. This atomizer comes with threads, so you can screw it into either the manifold or a threaded T fitting.

If you want to spend more money and get a totally automated cold-start system, you can purchase a thermostatic switch. When the engine block water is above some preset temperature, usually 90°F, the thermostatic sensor switch stays open




DAVID BLUME

***Fig. 17-4 Commercial ether start system.*** *Although commercial systems are more expensive, they deliver a measured amount of ether, which more or less idiot-proofs the system against flooding the engine with explosive ether. On the right (from top to bottom) is a momentary contact switch for manually starting, a thermostatic switch to be attached under any bolt on the block, and a very nice atomizer to be threaded into a drilled and tapped hole in the manifold. The roll of tubing on the left is used to connect the valve to the atomizer.*



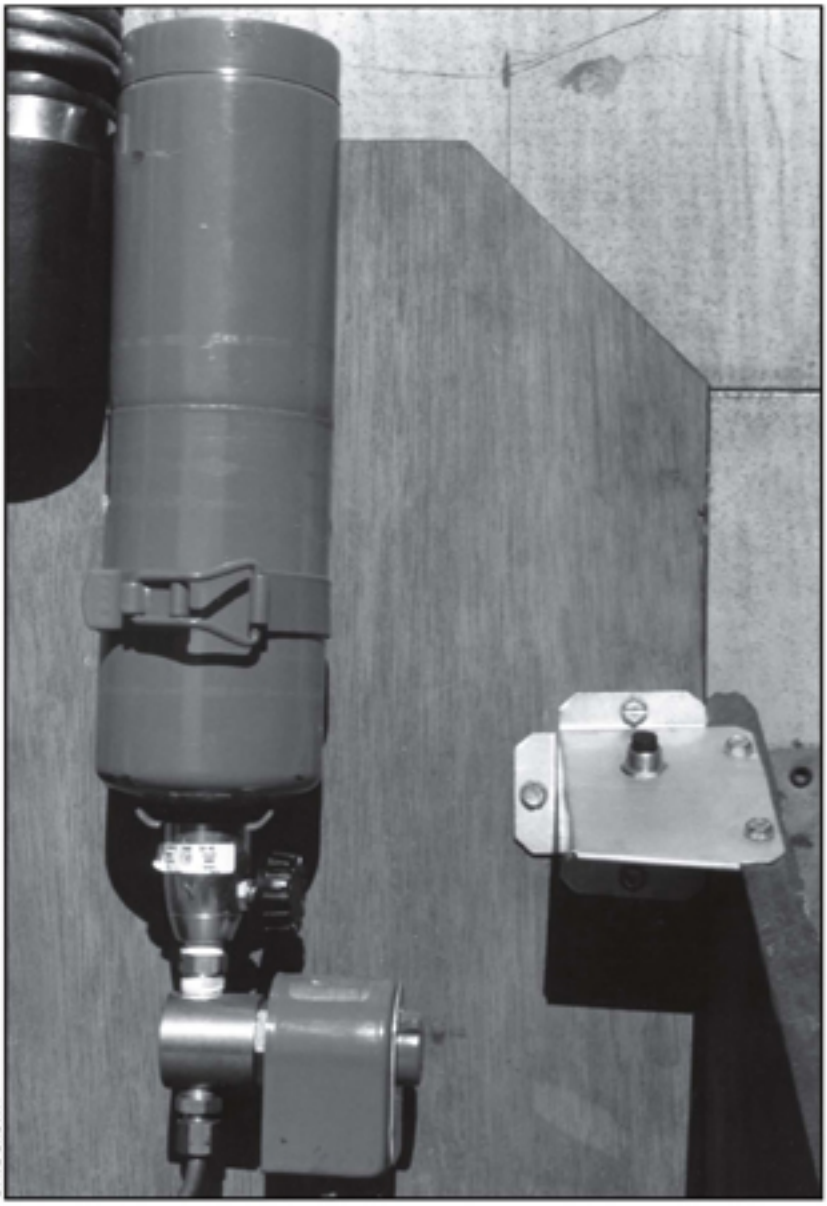
MATT FARRUGGIO

***Fig. 17-3 Cutaway model of PCV-type cold-start fuel injector.*** *This model is intentionally oversized to illustrate its construction. The tube should be 1/8 inch with the end soldered and drilled with a tiny hole (the same way this 5/16-inch line has been constructed). The hole would actually point to the left, in the direction of the airflow, and the compression fitting would be a 3/8-inch mip × 1/8-inch compression adapter. Hose barbs should be 3/8 inch for most PCV lines.*

and won't allow electricity to pass though and open the ether solenoid valve. When you turn the car key and the engine block water is below 90°F, the circuit is allowed to complete, and ether runs into the manifold.

This system is not manual. The thermostatic sensor is simply screwed into your block or water system and wired to both your key and the temperature sensor on the way to the ether cold-starter's solenoid valve.

Ether bottles are good for about 600 shots. On a very cold morning, your engine may require one or more shots before the engine starts, but ether is the surest of engine starters. Even in cold climates, you



DAVE BROWN

***Fig. 17-5 Propane cold-start system model.*** *The normal propane torch nozzle is removed, and a solenoid valve is attached in its place and wired to the dashboard. A push of the button releases liquefied gas into the manifold to start the vehicle. As the pressure of the fluid drops inside the manifold, the propane should almost completely vaporize. Make sure the valve is a lock-off type that doesn't let propane seep when closed.*

## ADDING ETHER TO DENATURE ALCOHOL

If we follow the route of adding a volatile to alcohol, for cold-starting or denaturing, there are much better solutions than gasoline or isopentane. Diethyl ether is even more effective, ounce for ounce, than isopentane, if added at low levels; 6% ether has been found to be as effective as 10% isopentane. The nice thing about ether is that it's often produced from alcohol.

In the ASTM specifications for E-85, ethyl ether is allowed, so technically you should be able to meet these specifications without using gasoline. Older, high-quality chemistry books will tell you how to make it. Ether is extremely explosive, and you must be extremely careful about its production. So this tends to be a "don't try this at home, kids" sort of thing.

Low percentages of ether will raise your combustion temperature slightly but still below gasoline's combustion temperature. Because of its high oxygen content, ether also has a slight emission-reducing effect on ethanol's already tiny tailpipe emissions (whereas isopentane increases them).

Although you are unlikely to actually work with ether, it is usually stored in five-gallon steel drums, in a well-ventilated place, preferably a shady spot outdoors. Ether should be pumped at a cool, even cold, temperature—using a totally enclosed explosion-proof pump—into cool alcohol. Never pour it into the alcohol through the open air. Inhaling ether can anesthetize you before you know it. And long exposure to ether vapors can kill you.

Pumping liquid ether into liquid alcohol, however, should eliminate the hazards related to vapor releases. Ether fires will burn fiercely but, like alcohol fires, can be extinguished with water.

As the lawyers say, "Tell them they should leave this to professionals." Consider yourself warned.