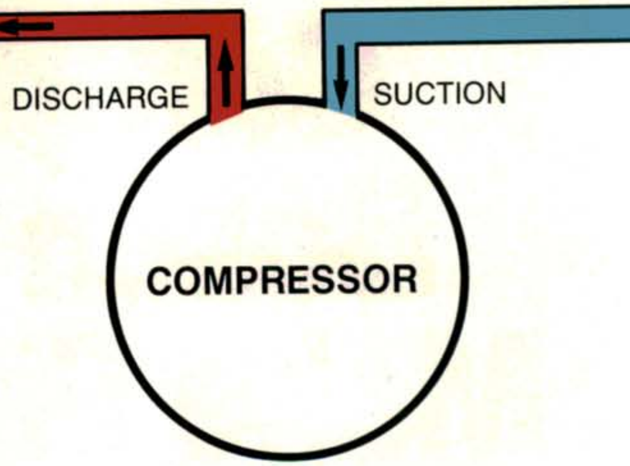
Basic Air Conditioning



Those of us still mired in the nastiness of an Ohio winter are looking forward to the day when a dozen customers wander in, suffering from the heat, and want their auto air conditioners serviced. Those of you basking in the sunny climes of the South and West happily find air conditioning a less seasonal proposition.

Either way, we offer this month's Basic Training on the fundamentals of air conditioning. We'll look at the physical laws involved in the operation of an air conditioning system, and discuss the hardware needed to make these laws work for us.

Reverse Psychology

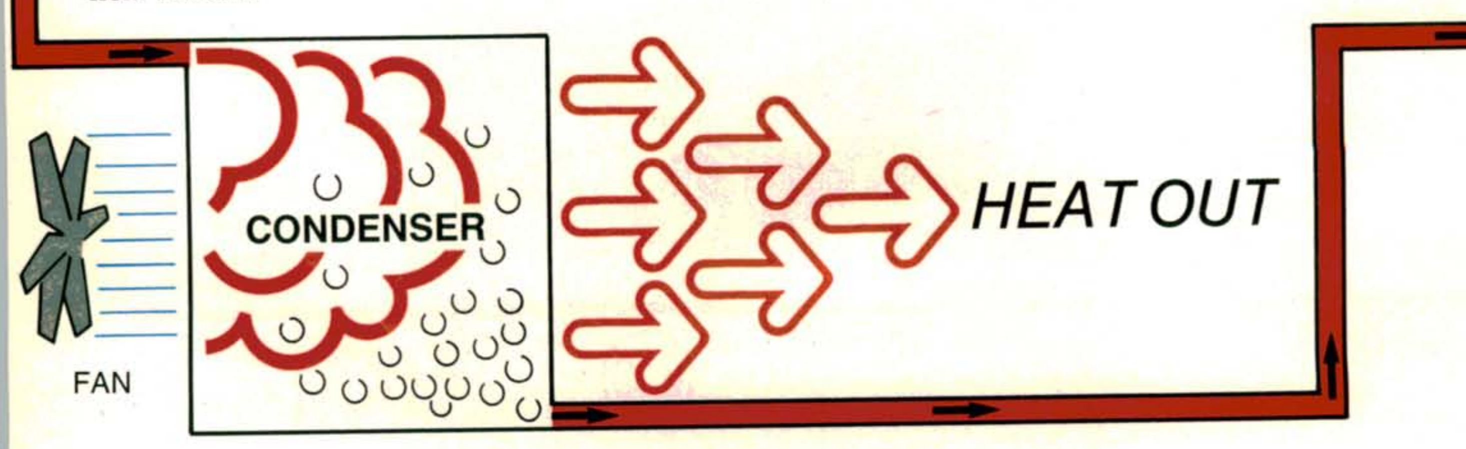
Basically, an air conditioner is a means of moving heat from a place we don't want it, to another place where it won't bother us. A familiar example is a car's heater. Excess engine heat is absorbed by circulating coolant. It passes through a small radiator with a relatively large surface area, more commonly known as the heater core.

Heat is radiated into the cabin of the vehicle. If we add a fan and place it behind that radiator, or heater core, we can speed the rate of heat transfer. We are transferring heat from a place we don't need it to a place where it'll do some good; namely clearing our snowy windshields and protecting our toes and fingers from frostbite.

If we want to cool the car on a hot summer's day, however, we'll have to reverse this process. We need a "heat sponge" to soak up that excess heat from the cabin. Then we'll need some way to wring that sponge out and remove the heat we soaked up. (Of course, we'll want to wring it out somewhere outside the cabin.)

The sponge probably won't absorb all the excess heat the first time around, so we'll have to find some way to cool it and reuse it, over and over again, until we remove enough heat from the car to make it comfortable.

The sponge is called R-12, a chemical that boils at -21.6 degrees F. We know it as freon in the shop. ("Freon® " is a registered trademark of E.I. DuPont Co.)



Basic Laws-Working Principles

R-12's extremely low boiling point will enable us to use the following characteristics of gases and liquids:

- Heat moves from hot to cold; from areas of greater heat to areas of less heat.
- When materials change from a liquid to a gas they absorb heat.
- When materials change from a gas to a liquid they give off heat.
- For a given temperature, there is a corresponding pressure. For a given pressure there is a corresponding temperature.
- The boiling point of a liquid will vary with its pressure.

Making It Work

Let's start at the compressor. The compressor is a pump used to keep R-12 moving through the air conditioning system. The gaseous R-12 being sucked from the evaporator has acted like that sponge we talked about earlier. It has absorbed heat from the cabin of the car. The compressor draws that "low side" R-12 through its inlet, or suction side, and compresses it to raise its pressure. Increasing its pressure raises its temperature. Remember, a compressor is made to handle gases, not liquids. If you ask it to compress a liquid, you're asking for trouble.

This compressed R-12 travels to the condenser next. The condenser is basically a high pressure radiator. The R-12 is a lot hotter than the outside air, and since heat travels from hot to cold the heat is surrendered to the outside air. If we add an electric fan to move air through the condenser, we can speed the process.

As the R-12 moves across the condenser, it loses enough of its energy to the outside air that it condenses back into a liquid.

Not-So-Wide Receiver

The R-12 comes out of the condenser as a hot liquid. Next it travels to the receiver/drier. The receiver/drier does a number of things. It contains a desiccant or drying agent which removes small amounts of water from the R-12.

Receiver/driers also have a sight glass which allows the technician to view the flow of R-12. Some have low pressure cut-out switches mounted in them. Some have fusible plugs that melt at extremely high temperatures providing a pressure relief. These prevent damage to the system when temperatures and pressures get too high.

Cooling the Cabin

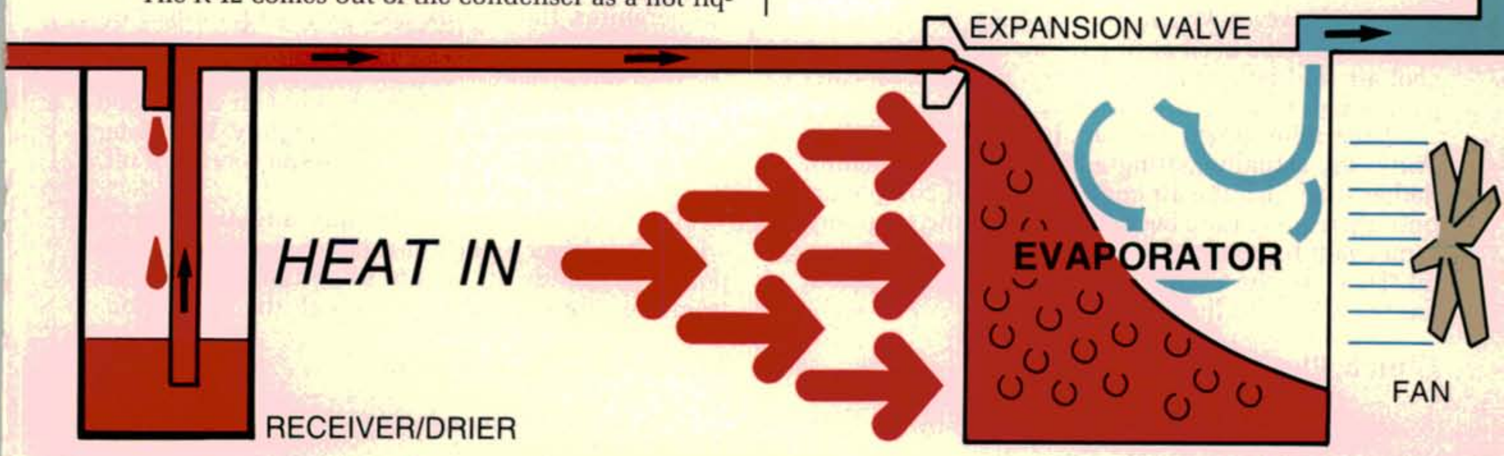
The evaporator does what the condenser does only in reverse. High pressure R-12 enters the evaporator inlet through the expansion valve. Stop here for a moment and remember that the evaporator outlet is connected to the suction side of the compressor. High pressure at the inlet side of the evaporator and lower pressure, or suction at the outlet side, keep R-12 moving through the evaporator.

The expansion valve controls the flow of R-12 through the evaporator. This valve responds to the temperature of the evaporator and allows enough freon to pass to maintain evaporator temperature at a constant level.

The expansion valve acts like the ticket taker at the Super Bowl. Equipped with a phone hook-up to the grandstand (an electrical or mechanical sensing device in the evaporator) and a turnstile (a control valve), he allows only as many ticket-holders (R-12) to pass the gate as there are seats in the stands. If he receives a message that some have exited, he allows a few more in. The seats are always full, but never overflowing.

Mason-Dixon Line

Let's spend a few more moments looking at the expansion valve. It is vital to the proper operation of the air conditioning unit.



It is the Mason-Dixon line of the system, separating the high side from the low side. Remember, we have a high pressure liquid trying to enter the evaporator through the expansion valve, and a lower pressure at the outlet side of the evaporator created by the suction of the compressor.

A "pigtail" or capillary tube is clamped tightly to the evaporator outlet. If the temperature at the outlet side goes up, the charge in the closed tube expands and forces a diaphragm open. This diaphragm pushes the valve in the expansion valve farther open and allows more R-12 to enter (or ticket-holders if you like the analogy).

With the valve open, more R-12 is allowed to pass. The increased flow of R-12 absorbs more heat and the outlet temperature of the evaporator goes down.

The charge in the capillary tube contracts from this lower temperature, releasing the pressure on the valve which slowly closes. This restricts the flow of R-12. Evaporator temperature goes down and the cycle is repeated.

put of cold air is to cycle the current controlling the compressor drive clutch. To do this, we'll need to install a couple more "phone lines" to relay messages. We'll also have to hire that ticket-taker's brother-in-law and put him to work. (Finally!)

We'll call the new man the *thermostat switch* and put him to work manning those phone lines. One line comes from the driver who requests a certain temperature he finds comfortable. As long as it's warmer in the car than the driver wants it to be, the switch will stay on the line to the clutch and keep in engaged.

When it gets cold enough in the car to suit the driver, however, the temperature switch "hangs up" on the compressor and cooling is interrupted. When it gets warm in the evaporator again, the switch will dial the clutch and get the compressor turning again.

The frequency with which these on/off calls are made will depend on orders sent from the driver when he adjusts the temperature control.

As the R-12 enters that area of low pressure created in the evaporator by the compressor, it absorbs cabin heat, and changes from a liquid to a gas. (Remember, R-12 boils at -21.6 degrees F. Our temperature "sponge" is at work.)

You might think that the exiting R-12 would be pretty hot, considering that it's soaked up quite a bit of cabin heat. Remember, however, that we're on the low pressure side of the system. Even the hoses are bigger. So even though the R-12 has absorbed a great deal of energy from the cabin, the reduced pressure on the outlet side reduces temperatures correspondingly.

Too Hot? Too Cold?

We've all seen those little window air conditioners with only two settings--namely "on" and "off". These units usually run full blast until you get cold enough to shut them off for a while.

We'd like a little more control over our auto air conditioner, however. When we first open the door of a closed car that's been sitting in the hot sun, we want cool air, and lot's of it, in a hurry. Usually, we can't get enough cooling in those first few minutes.

A few miles down the road, however, we may find things are actually getting a bit chilly in the cabin. Rather than turn the air conditioning off completely until the temperature becomes too hot, and then turn it on again full blast, we'd like to just turn it down a bit. That way, the temperature stays just right, without too many drastic fluctuations.

Clutch Player

One of the most common ways to control the out-

Again Please?

The thermostat switch works on the same principle as the expansion valve. A capillary tube, filled with a charge, and sealed, is installed in the evaporator coils. Expansion and contraction of the charge moves an electrical contact to make or break the current feed to the compressor clutch.

While this switch, like the expansion valve, is not adjustable in the field, placement and depth-of-insertion of the capillary tube in the evaporator can affect cooling. Improper placement, a broken capillary tube, or a mechanical failure in the switch can prevent proper cooling.

An Alternate Method

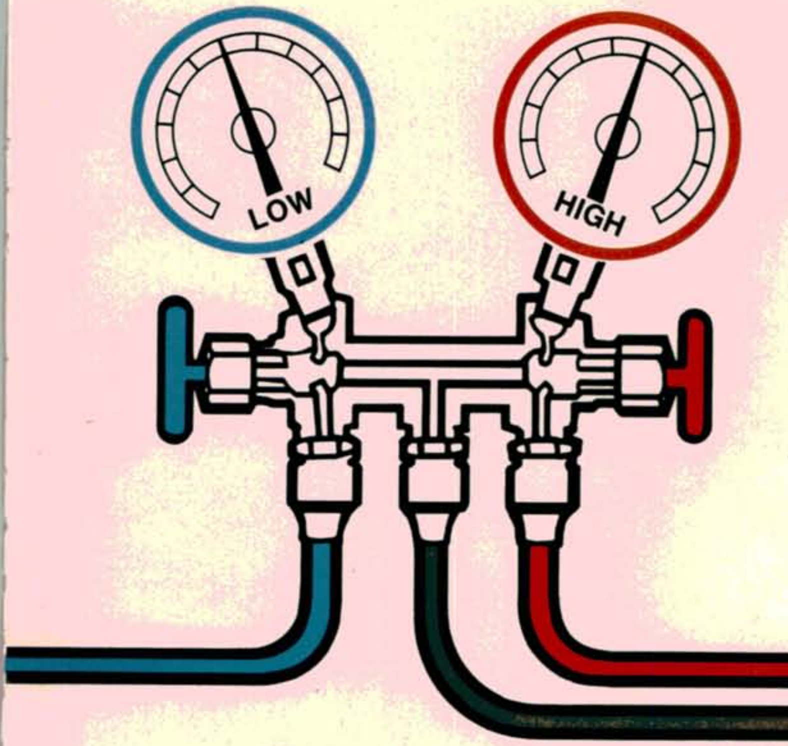
Some systems allow the compressor to run constantly. A constant temperature is maintained in the evaporator as a result. In order to control duct temperatures, the air mix door gets the messages instead of the compressor clutch.

With this system, when the air gets colder than the setting selected by the driver, the cold air is diverted through the heater core to warm it slightly. The heater control flaps probably won't be all the way on or off, but somewhere in-between.

The exception to this air-mix situation occurs when the driver selects maximum cooling. In this position, oustide air is shut off. Already cooled air from the cabin recirculates through the evaporator.

Variations On A Theme

We humans are ingenious little beings. We're



always looking for ways to build a better mouse trap. As a result, we've added a lot of control devices to the basic system outlined above.

These devices vary in sophistication. They also vary among manufacturers. They are not always essential to basic cooling. They are designed to protect the system from damage in extreme conditions, protect the engine from the super-high temperatures an air conditioner can generate, and improve driveability. Here are a few of the more common "add ons":

- The Low Pressure Cut-Off Switch—This switch is usually located in the receiver/drier, although not always. If system pressure fails to a point where the compressor could be damaged, current is interrupted to the compressor drive clutch.

- The Ambient Temperature Switch—This sensor is usually located in the duct supplying outside air to the evaporator. If the ambient temperature falls below a certain point, say 38 degrees F, this switch will also cut the power to the compressor drive clutch.

- Pressure Relief Valve—This pop-off valve is like the one on mom's pressure cooker. Located on the compressor, it will open and relieve excess pressure in extreme cases. It closes again when the pressure falls to a safe level.

- Coolant Overheat Switches—Since the heat pulled from the condenser must also pass through the radiator on most cars, engine coolant overheating can result in some cases. This switch interrupts the compressor clutch current until things can cool down a bit in the cooling system.

- High Pressure Switch—This switch will turn on the cooling fan when high side pressure reaches a certain point (usually about 200 psi). In some cases, a two speed fan is used and the switch calls for high speed when pressures get too high.

There are other, more subtle modifications in use. They include computer and vacuum operated controls too numerous to mention now. Be aware that they do exist, and refer to the specific applications for the vehicle you're working on.

A Few Cautions—A Few Limitations

R-12 is colorless, odorless, non-explosive, and nonflammable. So it's hard to believe how dangerous it can be in the wrong hands. Every time I see a weekend warrior DIYer in a department store parking lot with a can of R-12 in his hands and the hood of his car up, I head for the hills.

For your own safety, please note the following precautions when handling that seemingly innocuous, harmless gas:

1) Get into the habit of wearing eye protection.
2) Avoid all skin and eye contact. The speed at which R-12 evaporates at normal atmospheric pressure can freeze and damage your skin and eyes.
3) Make sure you fully discharge any system before taking off any lines. Discharge the system slowly, through your manifold gauges. Properly vent the discharge.
4) Never apply heat to any part of the air conditioning system. Be careful where you aim that torch.
5) Never expose R-12 to an open flame. The gas produced is very poisonous. If you use a flame type leak-detector, make sure you have plenty of ventilation.
6) Never, never put liquid R-12 in the high side of compressor unless you like shrapnel. Manufacturers, concerned with novice safety, have even gone so far to change the fitting size on the high side of some compressors to prevent someone from doing this.

Now you know why I run from the guy in the parking lot.

—By Ralph Birnbaum