ROVAC

Revolutionary air-only cooling system proves successful in car tests

By E. F. LINDSLEY

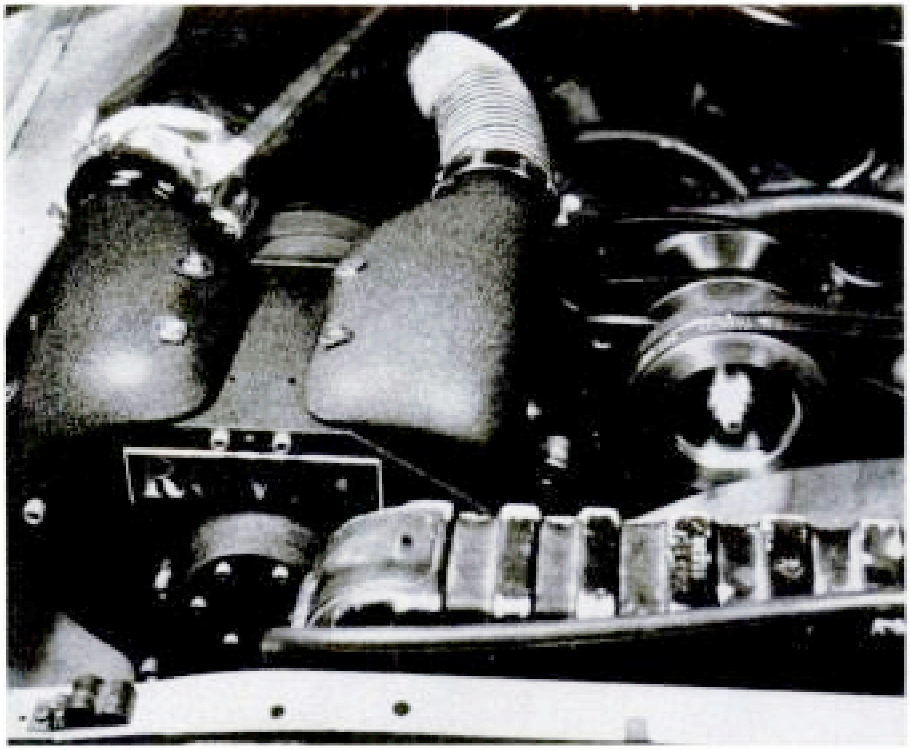
Under the glaring Florida sun a car with five sweating occupants rolls slowly down the road. Inside, Dr. Thomas C. Edwards' hand eases nearer a switch. In a few seconds he'll flip in the drive clutch and ROVAC will get its first real-life chance to prove that it can air-condition a car. It's the moment of truth for the no-Freon air conditioner young Edwards invented and has fought to produce since his first experiments at Purdue University [PS, Dec. '70].

Carefully, Edwards scans and records the indications of lab instruments rigged inside a Dodge Coronet test vehicle supplied by the Chrysler Corp. They show a stifling 107°F and 70 percent relative humidity. The five observers —including a Chrysler engineer— have been riding for ten minutes in the sun-baked car just to be certain that engine and body heat will make the test tough enough.

Admittedly, computer runs and bench tests had shown that ROVAC could drop temperatures spectacularly, and do it with amazing speed. Never, however, had a car actually been air conditioned with nothing but the air itself.

While driving at 30 mph, a perspiring Tom Edwards clicks his stop watch and switches on the circulator drive. All eyes focus on the thermometers. Almost instantly the first cooling blast sweeps through the steaming car. One minute and 53 seconds later the thermometers inside the car hover at 72°, design temperature for this first ROVAC installation.

The test went on—lugging at low speeds, idling at stop signs, cruising at 30-mph street speeds. These are the worst possible conditions for any engine-driven air conditioner. Faithfully, the small black circulator under the hood sucked in hot air and pumped out cool air.



ROVAC test unit, installed in Dodge, is pulley-driven like conventional air conditioner, has heat exchanger mounted in front of car's standard radiator.

Jubilation, uncommon for hard-nosed engineers, came through in their voices as they congratulated Tom Edwards. After four long years, always working against loud put-downs from established giants in the Freon-dependent refrigeration industry, Dr. Edwards' rotary-vane air cycle (ROVAC) had proved its potential.

A long road

Frankly, it hadn't been as easy as it looked from Purdue in 1970. In fact, it hadn't even been as easy as it seemed in August '73 when Popular Science reported that Tom would install the first ROVAC in a four-door automobile under Chrysler auspices.

There were machining problems, mechanical problems, noise and efficiency problems, drive problems,

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Tiny vanes cool air by alternately compressing and expanding it

Hot passenger-compartment air is ducted into compression side of ROVAC circulator. Compressed by the whirling vanes, air's pressure doubles and temperature soars to 285° F. Air is then blown through heat-exchange tubes, which are cooled by outside air moving through finned exchanger. Now cooler (113° F) but still compressed, air enters expander side of circulator. As air expands to atmospheric pressure, it cools adiabatically to a cold 43° F before reentering the passenger compartment. Small drawing below shows how ROVAC vanes make frictionless yet airtight contact with housing.

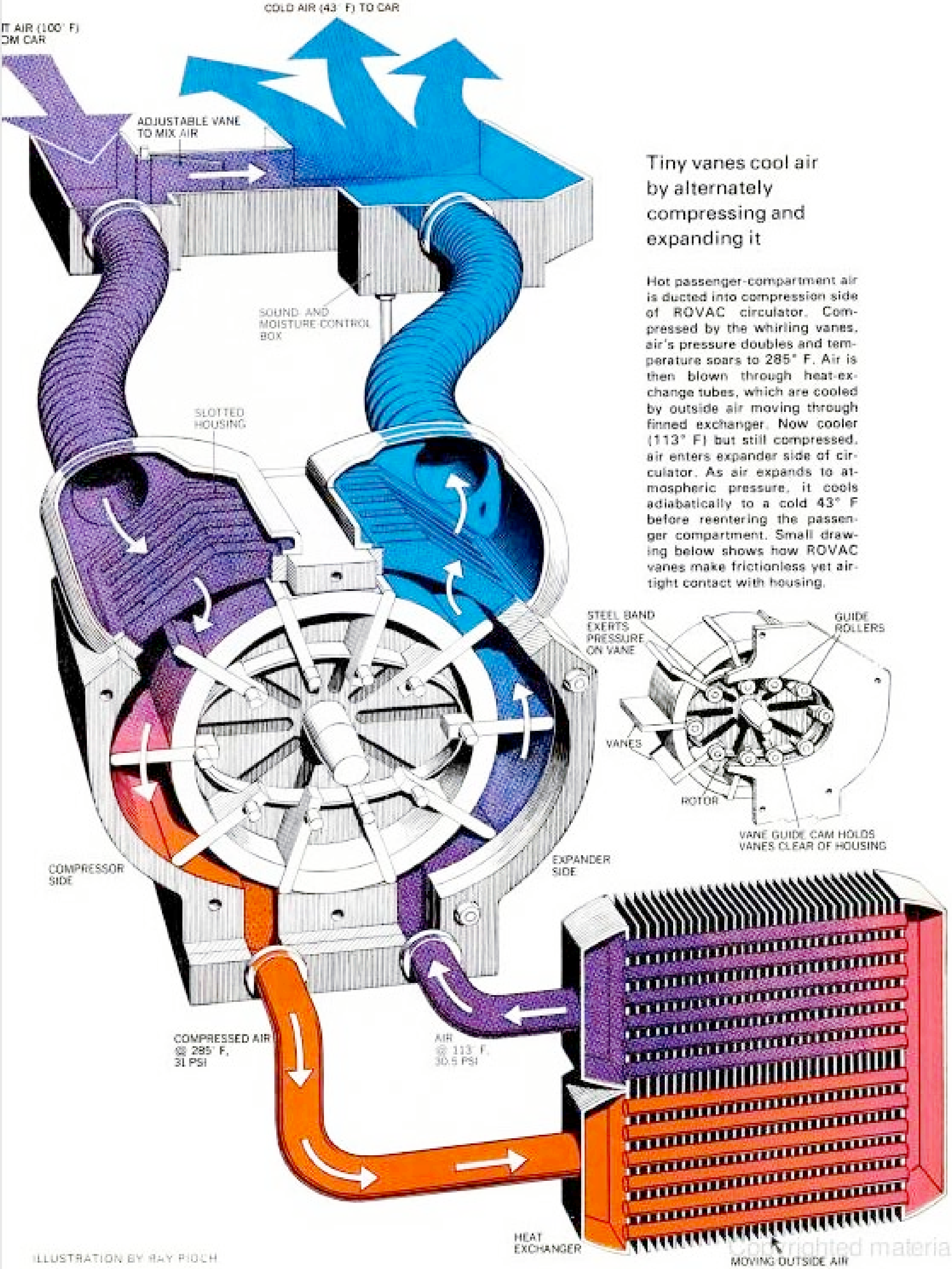
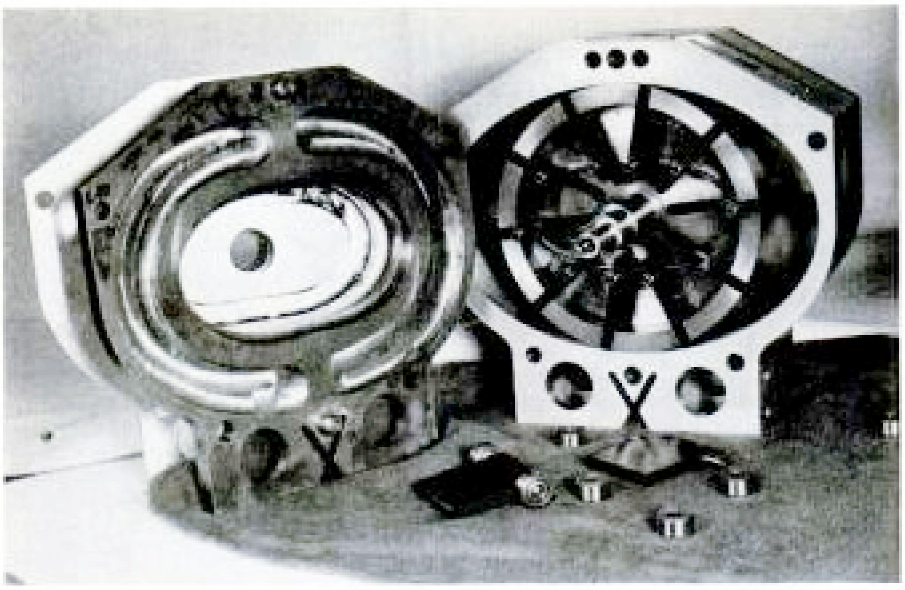
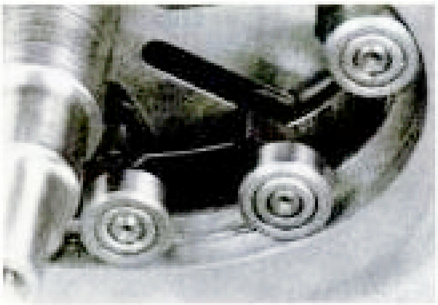


ILLUSTRATION BY RAY PIOCH





Inside ROVAC's air circulator (above), an ingenious sealing system minimizes friction and leakage between the turbine-like vane tips and housing. Right-angled shaft through base of each vane connects it to a small roller bearing (left) that runs in an oval track matching the oval-shaped housing. Shaft passes through a slot in rotor and is tensioned by flexible steel band to maintain precise 0.001-in. tip clearance as vane moves in and out during each rotation.

and others. But there was also Tom's abiding faith that ROVAC would work, and one by one the problems were solved or reduced to acceptable levels. Late in the tests, to Edwards' surprise, a bonus showed up: unexpectedly better performance. Atmospheric moisture was playing hard-to-analyze, but helpful, tricks.

Even so, Freon systems have been doing a good job for years. Why get excited about ROVAC, even if it doesn't use Freon? There are some important reasons:

- No Freon means no high-pressure gas to store, seal against leaks, or replace. The whole ROVAC system is simpler.
- ROVAC's demonstrated coefficient of performance (COP) already exceeds that of conventional Freon types. Thus, ROVAC takes less power from the engine than a conventional air conditioner, reducing fuel consumption.
- Instant cold. From start-up to cold air, ROVAC is so fast there's no detectable time lag.
- Instant heat. Heat from ROVAC's intermediate coils is available for defrosting long before the engine warms up.
- Controlled moisture output. In reefer trucks, ROVAC can keep meat and other foods from drying out when cooled, a common problem with conventional refrigeration.

How it works

We've explained in previous stories how the rotary circulator that alternately compresses and expands the air operates, but now we have details that weren't available before. Freon units use a reversed Rankine cycle with a gas-to-liquid-and-back-to-gas phase change. Rovac uses no phase change, except for the incidental moisture normally present in the air. Edwards calls this a reversed Brayton cycle. Anyone who has ever ridden in a commercial jet aircraft has probably experienced its cooling effect, from a turbine. The challenge was in reducing the principle to hardware that would fit under your hood, or in a window air conditioner.

ROVAC's oval-shaped housing acts as a compressor on the inlet side and an expander on the exhaust side. In a typical situation, air enters the compressor at 110°F and 14.65 psi, or whatever the atmospheric pressure happens to be at that time and place. It leaves the compressor at about 31 psi and 285°F. The increase in pressure and temperature represents energy borrowed from the car's engine. From the compressor the air travels through a finned heat exchanger with rather large tubes. Here, outside air flowing past the tubes cools the air inside and drops the pressure slightly, so that going back into the expander side, the air would be about 113° at 30.5 psi.

Going through the expander, a part of this heat/pressure energy is returned to the vaned rotor—very much as steam drives a turbine. Result: in the expansion process, the air "pays back" a substantial part of the power it borrowed from the car engine to compress it originally. When the air leaves the expander, of course, it's at atmospheric pressure, but its temperature is 43°F.

In practical terms this describes a typical automotive-size ROVAC rotating at 1350 rpm and delivering over 20,000 Btu of cooling per hour. It can be designed to produce outlet temperatures well below freezing or to direct 130° heat from the exchanger onto the car's windshield instead of dumping it outside. Modulation and moisture control is handled in the distribution ducts.

Debugging the system

The ROVAC's vane tips must run very close to the housing walls and fit very snugly in the rotor slots if efficient compression is to be obtained. But they can't run too close and too tight without lubrication; nor do you want oil vapor in the air that blows back into the car. Some low-friction materials looked promising, but there were still "cocking" effects that forced the vanes against the rotor slots. The clever solution is shown in the photos above.

Noise from a ROVAC running with open ports sounds like the exhaust from a small engine. In the test car, however, noise coming through the ducts was effectively silenced. Noise reflected up from the road and back from the hood area is apparent, however. Edwards doesn't expect this to remain a real problem.

Right now, the test car is in Detroit. "Automotive interest is flourishing since our successful trials," Tom Edwards says. But there are still manufacturing and tooling considerations, as well as marketing decisions, that will affect its fate. Whatever happens, the ROVAC principle is too well suited to too many other jobs—truck refrigeration, aircraft heating and cooling, even home air conditioning—for it to be ignored. ■