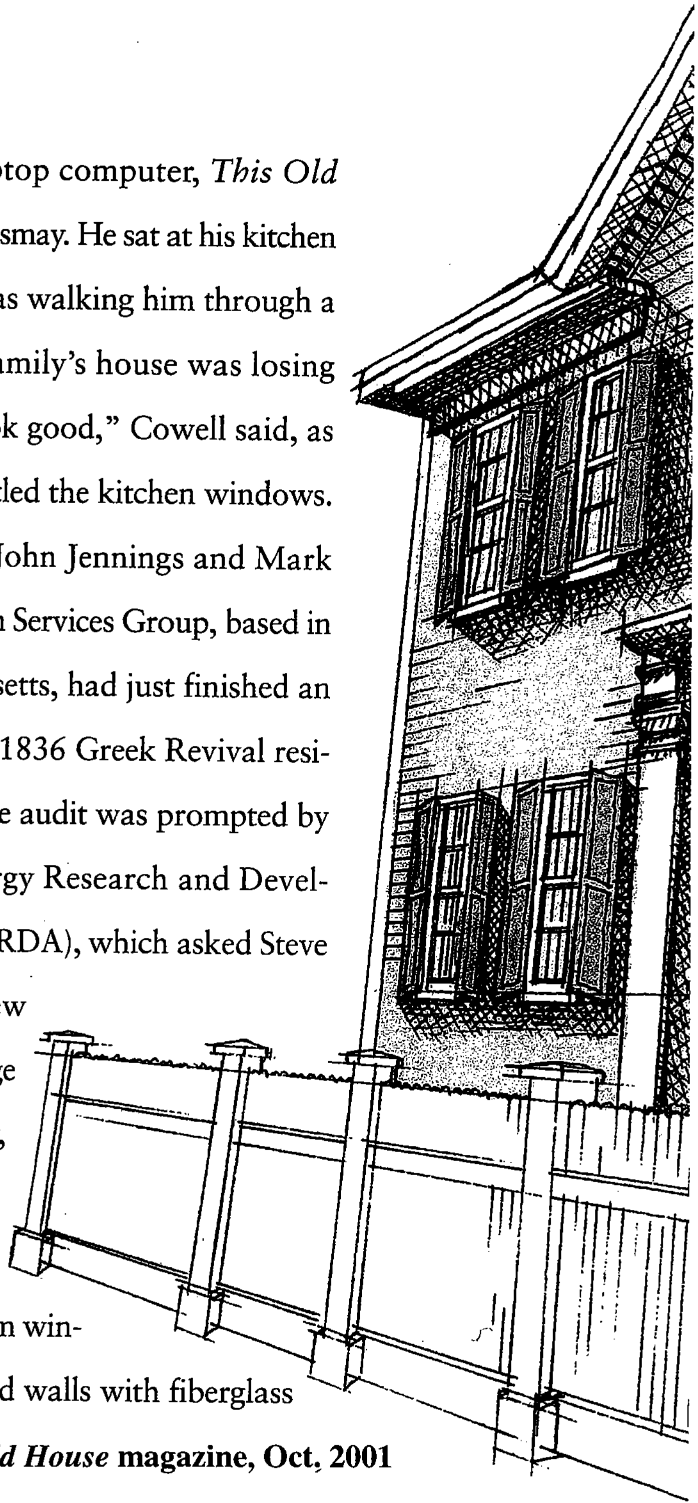
Keeping in the **Heat**

A checkup of Steve Thomas's old house spurs the *T.O.H.* host to lower his energy bill

His face illuminated by the blue glow of a laptop computer, *This Old House* host Steve Thomas took the bad news with obvious dismay. He sat at his kitchen table with Stephen Cowell, a home-energy expert, who was walking him through a spreadsheet that showed how much heat the Thomas family's house was losing every day. "It doesn't look good," Cowell said, as a frigid January wind rattled the kitchen windows. Cowell and technicians John Jennings and Mark Hutchins, of Conservation Services Group, based in Westborough, Massachusetts, had just finished an energy "audit" of Steve's 1836 Greek Revival residence in Salem, Mass. The audit was prompted by the New York State Energy Research and Development Authority (NYSERDA), which asked Steve to help publicize its new energy-conservation program. (See "Where to Find Help" page 115.) Because old houses are object lessons in inefficiency, Steve offered up his as a test case, although he figured it would perform pretty well. "In the 15 years I've owned this house," he says, "I've upgraded the heating system, replaced the storm windows, installed weather-stripping, caulked crevices, and filled walls with fiberglass

Using special spreadsheet software on a laptop computer, home-energy expert Stephen Cowell (right) shows T.O.H. *host Steve Thomas how much heat his house is losing, and how much money he can save by tightening up its envelope and upgrading its heating system.*



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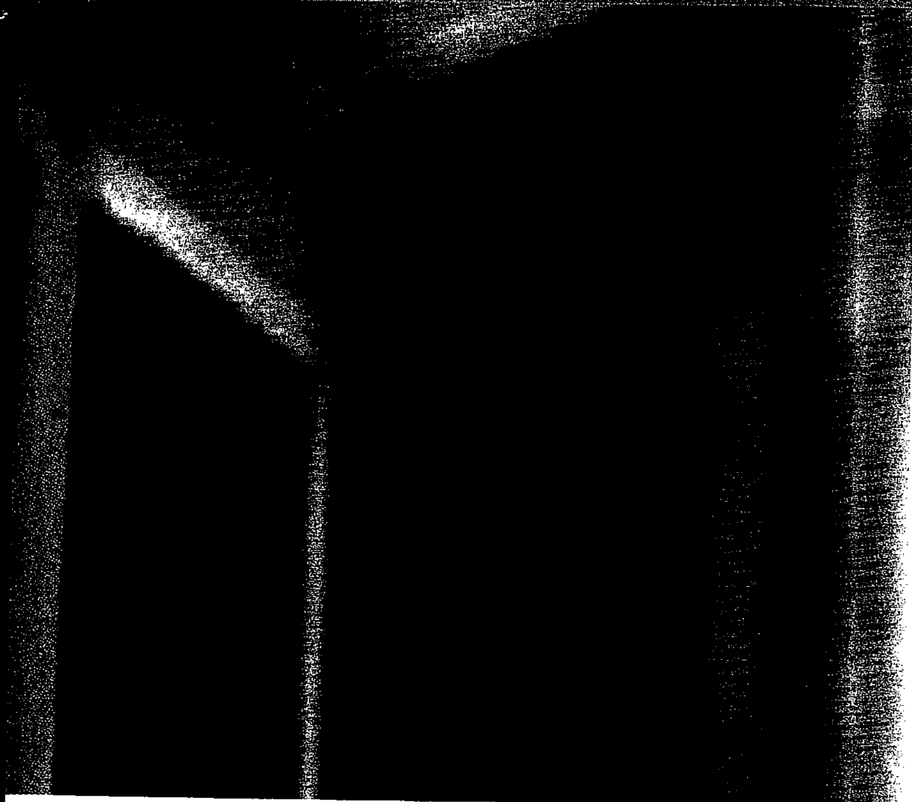
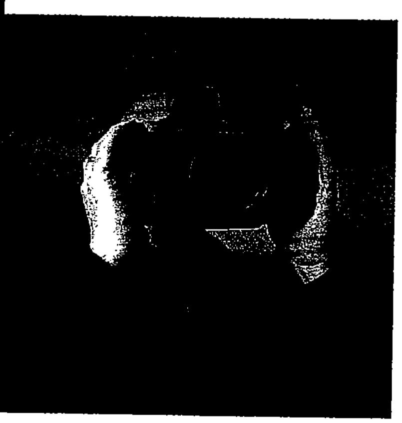
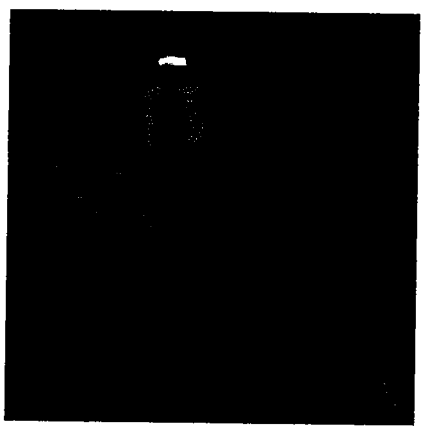




LEFT: For finding escaping heat, a thermal imaging scanner is the high-tech tool of choice. This videocam-size device detects infrared waves and translates them into colors or shades of gray. ABOVE: *When the imager is taken indoors, the purples, blues, and blacks highlight where the insulation has slipped and is allowing heat to escape.* BELOW: *The whites and yellows show where warmth is exiting a roof and chimney, while the darker colors indicate cooler, better-insulated surfaces.*



insulation." Nonetheless, Cowell showed Steve that each hour, 70 percent of the warm air inside his house was seeping out through invisible gaps and cracks in the walls and roof. (The ideal minimum amount is just 35 percent, or .35 air changes per hour.) Added together, these openings are nearly the equivalent of punching a 1½-foot-diameter hole through one of his walls. Cowell's test of Steve's natural-gas boiler and water heater showed that, while both were running fine, they burned at least 15 percent more fuel than comparable new systems would.

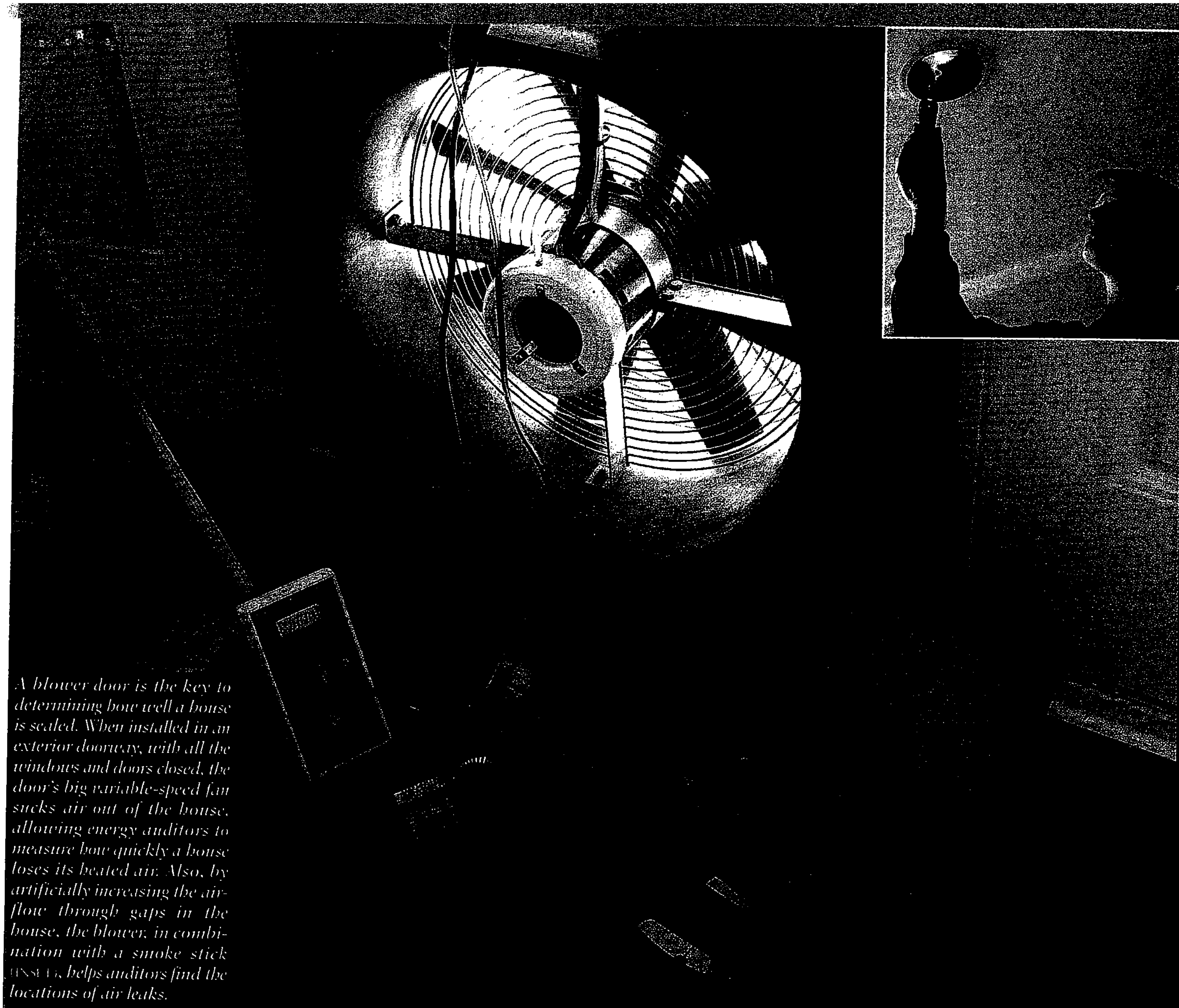
"Most homeowners, even those in new houses, don't realize that their energy bills are much higher than they need to be," says Cowell. Based on the 35,000 energy audits his firm conducts each year around the country, Cowell says the average homeowner can generally save 15 to 25 percent on heating and cooling bills just by adding insulation and plugging air leaks, and another 15 percent by upgrading heating, air-conditioning, and hot-water systems that are 10 years old or older.

TESTING FOR LEAKS

Cowell's first stop on his audit was Steve's kitchen, where he replaced its exterior door with a blower door, a device with a big fan and air-pressure gauges, which measures how much air leaks into a house and helps pinpoint the leaks. After closing all the windows and exterior doors, opening all the interior doors, and shutting off the boiler and water heater (to prevent their exhaust from being pulled back into the house), Cowell sealed the blower door tightly to the door jamb and turned on its variable-speed fan. In just three minutes, it sucked enough air out of the house to lower the inside pressure, as measured with a digital manometer, by about one pound per square foot, the standard for all such tests. He then adjusted the fan's speed and measured the rate at which it had to keep exhausting air in order to maintain the lower pressure. The exhaust rate—4,800 cubic feet per minute—wasn't bad for a 165-year-old building, but still, the fan was sucking out twice as much air as it would in a properly sealed house. "I was very surprised," Steve says. "I'd noticed that the house cooled down quickly in winter, especially on windy days, but I didn't think it was that leaky."

What the blower-door test didn't tell Cowell was where the leaks were. To hunt them down, he left the blower door running and checked the walls and ceilings from attic to basement with a smoke stick. When squeezed, this candle-size tool produces an easily disturbed ribbon of titanium dioxide powder that makes the incoming drafts visible. (Without the blower door depressurizing the house, cold air creeps into a building too slowly to be noticeable.) He quickly uncovered the usual suspects—cracks between the mudsills and the foundation walls; leakage around an attic door at the third-floor landing; and gaps around recessed lights in the finished attic and master bedroom. "Recessed lights can turn the house envelope into Swiss cheese," Cowell says. He also found a stream of cold air coming in around the drain pipe under a second-floor bathroom vanity, which was nowhere near an exterior wall. The likely culprit: "wet" walls, says Cowell. "These narrow chases that carry plumbing up from the cellar are always a big problem."

Surprisingly, the old single-pane windows with their modern storms were not a major source of air leakage. Cowell found they accounted for just 20 percent of the house's total energy loss. Welcome news, because the commission that oversees the historic district where Steve lives would probably have balked at having the original windows replaced. In fact, having some drafts around windows and doors can be a good thing, in Cowell's view. "A house needs fresh air, and it's better to have that air come through windows and doors, rather than a moldy, mildewy basement." he says. That's why he recommends plugging leaks in the



A blower door is the key to determining how well a house is sealed. When installed in an exterior doorway, with all the windows and doors closed, the door's big variable-speed fan sucks air out of the house, allowing energy auditors to measure how quickly a house loses its heated air. Also, by artificially increasing the airflow through gaps in the house, the blower, in combination with a smoke stick (INSET), helps auditors find the locations of air leaks.

foundation walls and the roof first, before weather-stripping or replacing windows and doors.

As he made his way through the house, Cowell also checked the exterior walls and top-floor ceilings for poorly insulated (or uninsulated) areas, which lose heat through conduction, even if there aren't any air drafts. For this he used an infrared thermal-imaging scanner, a device that picks up infrared radiation emanating from surfaces and renders temperature differences visible, in shades of gray, on its monitor. There was plenty of cold for Cowell to see. The sloped ceilings and knee walls in the finished attic were only partially insulated, and the entire wall on one of the gable ends was missing insulation. As he aimed the scanner at the gable wall, Cowell saw wide swaths of black (the cold, uninsulated stud bays) with white vertical lines (the warmer studs) running through it. "No wonder this is the coldest room in the house," Steve said. "Now you can see exactly where insulation is needed."

The scanner also uncovered corridors of cold air infiltrating the house between the first and second floors. In the older, timber-framed part of the house, air found a path around the 6x6 girt beam and into the joist bays above the first-floor ceiling. The balloon-framed addition off the back of the house had the same problem. Steve had insulated the stud bays when he renovated the house, but there was no access to the framing between floors.

Cowell added up the wall and ceiling area in need of insulation, then fed the figure into a spreadsheet on his laptop along with the results of the blower-door test and a year's worth of Steve's fuel bills. The computer analyzed the numbers and instantly displayed how much heat the house was losing. It also showed that if the leaks were plugged and the stud and rafter bays were completely insulated, Steve could cut his energy consumption by 25 percent, knocking as much as $375 per year off his annual $1,500 heating bill. At current fuel prices, the cost of the insulation upgrade—about $3,800 (not including the $300 for the audit)—would pay for itself in 10 years; any hikes in natural gas prices would shave the payback time down even more. "When you look at it that way, the insulation—and installing it—is cheap," Steve says. "It's the fuel that's expensive."

SOLUTIONS

1. Install weather-stripping
2. Install storm windows
3. Install airtight covers
4. Seal openings in basement and attic
5. Blow in dense-pack cellulose
6. Blow in dense-pack cellulose
7. Seal with foam insulation
8. Blow cellulose insulation on floor, or spray foam insulation in rafters

Cold air moving into a house and warm air exiting account for most of the heat a house loses. Sealing the pathways with caulk, foam, or tightly packed insulation is the first and most important step in lowering heating (and cooling) bills; filling walls and attics with insulation also reduces the amount of heat lost through conduction. In Steve Thomas's house, adding more insulation cut heating costs by 25 percent.

ADDING PANES

Steve Thomas's efforts to make his house snug against the cold had him thinking like a lone man caught in a blizzard. "Whether you're sealing a home or zipping up your snow gear, keeping out cold wind works on the same principle," he says. Windows are obvious candidates for buttoning up; the Energy Efficiency and Renewable Energy Clearinghouse (EREC) reports that drafty window openings can account for up to 25 percent of a home's heat loss (or gain). Steve admits he would have preferred to install energy-efficient, architecturally correct replacement windows, but the cost of doing so was prohibitive, and the chances of getting such a change approved by the local historic commission were slim. So he went with the next best thing: aluminum-framed "triple-track" storm windows, so called because they have separate tracks for the upper and lower storm panels as well as one for the screen. For the ground floor, he chose panels with unbreakable polycarbonate plastic instead of glass, to protect the old panes from errant baseballs and the like. And to protect the sills from rot, he did not caulk the bottom of his storms. While it's impossible to predict precisely how much energy his storms will save, Steve and his family are certain to reap the comforts of a less drafty home this winter, and for a lot less money than the price of replacement windows. —*Dan DiClerico*

INSULATING THE WALLS AND PLUGGING THE LEAKS

To fill the empty stud bays and between-floor framing, Steve opted for blown-in cellulose. This insulation—ground-up newspaper treated with boron-based fire and mildew retardants—is ideal for upgrading older houses because of its high resistance to air and heat flow. (Cellulose has an R-value of 3.6 per inch of thickness, slightly higher than fiberglass batts, which typically measure R-3.2 per inch but offer little resistance to air movement.) When injected into cavities at a density of 3½ pounds per cubic foot, "It packs in so tightly there's hardly any air movement at all," says Cowell. Even better, because cellulose can be injected into existing cavities through 1-inch holes, the damage to the structure of the house is minimal and easily disguised.

The least messy way to install cellulose is from the outside, so insulation contractor Ray Williams and his Energy Guard crew began the project by carefully peeling off two courses of clapboard around the perimeter of the house at the height of the second-floor joists. Working from ladders, they drilled holes every 2 to 3 feet through the sheathing and the girt beams. Then they worked their way around the house, firing blower nozzles into the holes, until all the joist bays were filled with a deep blanket of tightly packed gray fluff. For the uninsulated walls in the attic gable, the crew drilled more holes through the sheathing at the top and bottom of the empty stud bays and shot in more cellulose. Then they plugged all the holes and replaced the clapboards.

Their last stop was the unfinished portion of the attic above the master bedroom. Its floor was already covered with fiberglass batts, which have a high R-value but could do little to stop the flow of air around the recessed lights in the bedroom below. (Fifteen years ago, Steve had placed plywood boxes over these fixtures to cut down on air leakage.) Williams buried the fiberglass and protruding boxes under 10 inches of cellulose. The cost for all this work, labor and materials, came to $2,300.

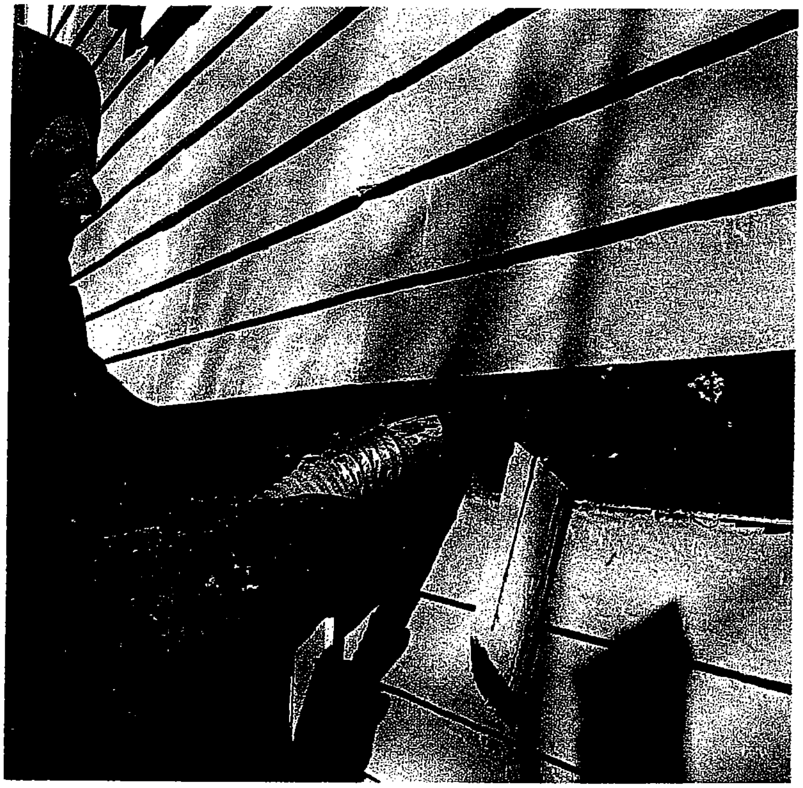
To tighten up the unfinished attic over the rear wing, Steve called in a second contractor, Anderson Insulation, to spray foam into the open rafter bays. This medium-density, water-based polyurethane foam has R-values similar to cellulose and creates a lock-tight barrier against air leaks. It also adheres to wood and masonry, making it ideal for exposed and overhead applications. A truck parked in Steve's driveway carried a machine that mixed and heated the two-part foam to 150 degrees so it could be pumped through hoses to the crew in the attic. After two crew members draped plastic around the area to contain the spray, a third, wearing a protective suit and dust mask, sprayed the underside of the roof sheathing with a thin layer of what looked, for a moment, like cream. In 30 seconds, the liquid ballooned 100 times in size, filling every crevice between the 2x6 rafters with a 6-inch-deep cushion of white foam and turning the frigid attic into a warm, draft-free cocoon.

Moving on to the cellar, the foam crew covered every nook and cranny between the stone foundation and the wood sills with the same material. "Sealing the sills solved all sorts of air-infiltration problems," Steve says. The cost of the foam insulation, including labor, came to about $1,500.

UPGRADING THE BOILER AND HOT-WATER HEATER

The final step in Steve's energy upgrade was to replace the 15-year-old boiler and gas-fired hot-water tank. When new, the boiler had an annual fuel utilization efficiency (AFUE) rating of 70, which means that 30 percent of the energy it burned went up the flue. "It's probably down to 60 percent now, due to its age," said Richard Bilo, the plumbing and heating contractor who installed the old system in 1986. The new boiler boasts an 87 AFUE—meaning 87 percent of the fuel it burns is converted into hot water for the baseboard and in-floor radiant zones—ultralow emissions of carbon dioxide and nitrogen oxides, and "smart" computer controls. Among other things, these controls eliminate the cyclic overheating that often happens with basic thermostats, continuously adjust hot-water output in response to outdoor temperatures, automatically lower and and raise indoor temperatures to accommodate travel and work schedules, and alert owners to any required boiler maintenance.

Bilo also replaced the gas-fired water heater with an "indirect"



LEFT: *With no insulation in the exterior wall area between the first and second floors, cold air had an open pathway into Steve's house. So after removing a few clapboards and boring a series of holes through the sheathing and the girt beam, a worker fills each joist bay with cellulose insulation until it reaches an air-blocking density of 3½ pounds per cubic foot.* ABOVE: *To stop air infiltration between the mudsill and the foundation, another worker sprays an expanding foam over the basement walls and ceiling.*

hot-water tank, one heated by the boiler. "Now, instead of two gas burners, Steve will have one," he said. This is significant because gas- and oil-fired hot-water tanks lose as much as 20 percent of their heat up the flue. Demonstrating his point, Bilo aimed a temperature sensor at the flue on the old tank, which he was about to disconnect. The gun read 112 degrees. "Just standing there, not even heating the water, it's sending hot air up the chimney," he said. The new tank has no flue at all—hot water from the boiler, fed through a closed loop of copper tubing, heats the water inside the foam-filled stainless steel tank. "It's like a Thermos bottle," Bilo says. "It loses less than one degree every four hours."

Steve's new boiler and hot-water heater are state-of-the-art and, predictably, costly. An installation like this, including plumbing, wiring, and removal of the old appliances, would run as high as $18,000. "Sure, I could have bought a boiler with the same efficiency for half the price," Steve admits. "But it wouldn't have given me the same comfort or flexibility, or been as good for the environment. It probably wouldn't have lasted as long, either. Mine has a 20-year warranty and should last another 20 beyond that."

A FINAL TEST

After two long days, complicated by a film crew documenting the work for NYSERDA, Bilo and the insulation contractors left behind a much tighter, more energy-stingy house. To find out just how tight, Cowell fires up his blower door one more time. Its gauge registers 3,600 cfm, a 25 percent reduction in air leakage since his first visit (about .5 air changes per hour). Combined with the savings generated by the improved insulation and the new heating and hot-water system, the projected energy savings come in at just over 40 percent, about $720 per year. "We got slightly higher than we were looking for," Cowell says. "Just as significantly, Steve's house is going to be a lot more comfortable."

For Steve, it was a clear lesson in how far energy-saving technology has come. "This house was as well insulated and efficient as I could make it 15 years ago," he says. "To increase that by another 40 percent is huge." After a thoughtful pause, he adds, "If every household in the country cut its fuel bills by that much, there wouldn't be an energy crisis."

WHERE TO FIND HELP

Steve Thomas's energy audit was arranged on behalf of the New York State Energy Research and Development Authority (NYSERDA), which helps New York state residents find qualified contractors to test and upgrade the efficiency of their homes and provides low-interest financing to pay for the work. (For more information, visit the NYSERDA Web site at www.getenergysmart.org; 800-222-0050.) Other states have similar programs, and some utility companies offer financial incentives (such as rebates or low-cost loans) to beef up insulation or to buy energy-efficient appliances. To find out about programs in your area, contact your local utility or state energy agency. You also can find helpful information at the following Web sites:

- **www.energystar.gov** The U.S. EPA's Energy Star Web site contains information on efficient appliances, building and remodeling techniques, a calculator that measures a home's energy efficiency, and links to listings for home energy contractors.
- **www.ase.org** The Web site for the Alliance to Save Energy has a "Home Energy Checkup" that measures how much you can save in annual fuel and electricity bills by upgrading insulation, sealing air leaks, and installing more efficient appliances.
- **www.eia.doe.gov** The U.S. Energy Information Administration Web site links to state programs and energy-related resources.
- **www.eren.doe.gov** The Energy Efficiency and Renewable Energy Network (EREN) of the U.S. Department of Energy contains information on energy audits and links to state resources.

PHOTOS: DAVID CARMACK