3.1 Introduction

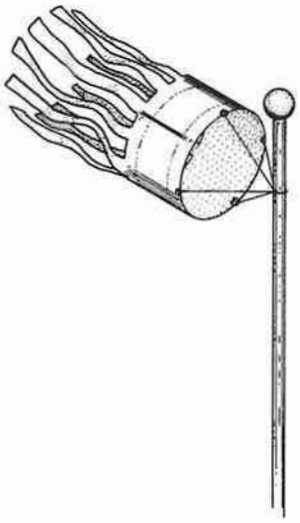
Ventilation brings fresh air into your home and can save up to 50 percent on cooling costs.

Ventilating works when the temperature inside is higher than the temperature outside. You can replace hot, stale, indoor air with cooler, fresh air from outdoors. (Solar gains and internal gains make indoor temperatures higher than the temperature outdoors; *see Section 2.2 Reducing Internal Gains, and Section 2.4 Reducing Solar Gains.*)

Several factors affect ventilation. Shade cools the air surrounding the house and reduces the accumulation of solar heat indoors. The more shade you have, the more ventilation can substitute for air conditioning.

Another factor is calm air versus moving air. Constantly moving air in the house feels cooler than calm air at the same temperature. Use ceiling fans and oscillating fans to maintain air movement in your home throughout the cooling season (*see Section 3.6, Indoor Air Circulation*).

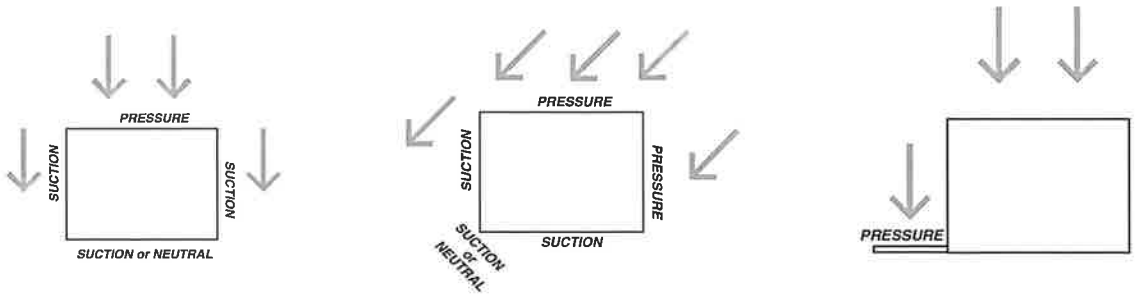
A third factor affecting ventilation is humidity. Ventilating during very hot and humid weather may not be effective if you use air conditioning most of the time. Air conditioners remove moisture from the air; opening the house to ventilate each day replenishes the indoor humidity. Air conditioning costs could actually be increased as much as 20 percent as the air conditioner works to remove the moisture every day. Outdoor air temperature should drop below 70°F before ventilating during humid weather.



***3-1 Wind Sock** - Natural ventilation takes advantage of prevailing winds. Wind socks show the direction of the breezes around your home.*

Florida Solar Energy Center researchers found that when apartments were ventilated at night during very humid weather, the water removed by the air conditioner increased from about 7 liters to about 26 liters a day.

Most people are uncomfortable when the relative humidity of the air is above 70 percent, or when the dew point is above 68°F. The dew point is the maximum temperature of a surface (like a glass) on which water from the air will condense. (*See Section 1.3, Elements of a Comfortable Environment.*)



3-2 Natural Ventilation - *Wind creates areas of pressure and suction around a home depending on the direction of the wind. Air flows in on the pressurized windward side. Air flows out due to suction on the leeward side. Solid objects can dam the wind and create a pressurized area.*

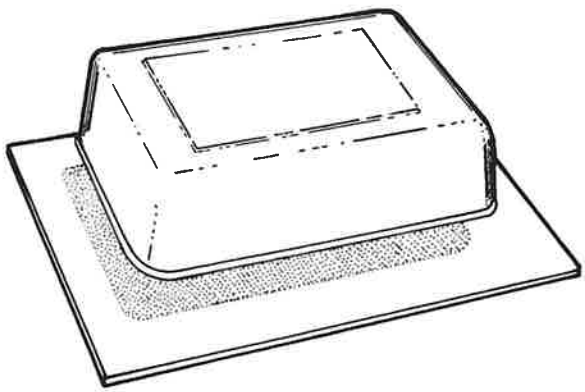
3.2 Natural Ventilation

Natural ventilation maintains indoor temperatures close to outdoor temperatures, and helps remove heat from the home. You should ventilate during the coolest parts of the day and night, and close the windows during the hottest periods.

A little wind allows you to ventilate successfully without fans until outdoor temperatures rise above 85° F. Wind creates areas of pressure and suction around the house. It will take some testing to determine which windows to open to maximize the benefits of natural ventilation. The windows near pressurized outdoor areas will be the cool air inlets, and windows near suction areas will be the warm air outlets.

Wind socks or wind vanes help determine the wind direction when deciding what combination of windows to open for maximum air flow (*see figure* **3-1**). Walls facing the wind are pressurized, and walls facing away from the wind are under suction or neutral pressure. Wind blowing parallel to a wall of the house generally creates strong suction at the window. Fences, thick hedgerows, or other buildings near the home can dam the wind and create a pressurized area, or channel the wind along a wall and create suction. Figure **3-2** shows areas of wind-caused pressure and suction around a home.

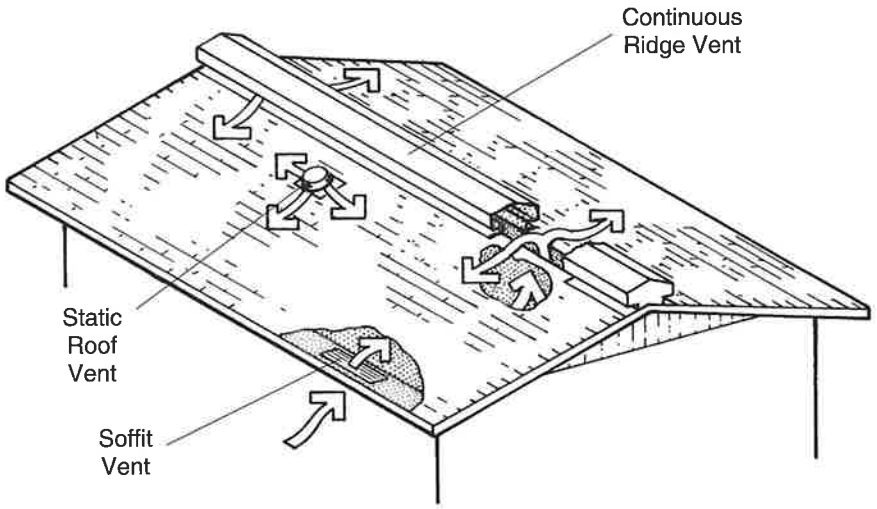
Inlets and outlets located directly opposite each other cool only those areas in the direct path of the air flow. More of your home will be cooled if the air must take a longer path between the inlet and outlet. Use smaller window openings for the inlets and larger openings for the outlets. This increases air speed and improves the cooling effect. Remember that air from shaded out-



3-3 Static Roof Vent - *This type of roof vent ventilates isolated sections of an attic. It is most effective combined with soffit and/or ridge vents.*

door areas is cooler and enhances natural ventilation.

Ventilation in two-story homes can be increased by using the natural buoyancy of hot air. Using windows that are low on the pressurized (windy) side of the home for intakes and high windows on the leeward side for exhaust can enhance ventilation through two-story homes. However, the wind is stronger and less obstructed by objects on the ground at second story windows, so they can be good air intakes, too.



3-4 Effective Attic Ventilation - *The most effective way to ventilate an attic without fans is to place the intake vents low, in the soffit; and place the exhaust venting high, in a continuous ridge vent.*

Experiment with different patterns of window venting to move fresh outside air through all the living areas of your home. This may involve leaving some windows closed if they interfere with moving air along a longer path through the house.

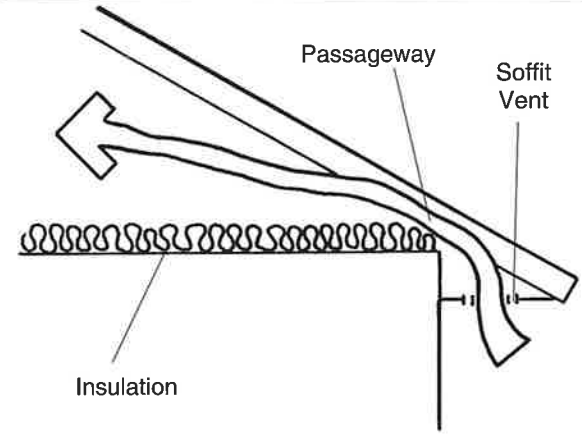
When you know how air moves naturally, you can decide how fans might enhance ventilation.

3.3 Attic Ventilation

There are two important reasons to ventilate an attic: to eliminate moisture that may accumulate in the insulation and other building materials during the colder months, and to cool the hot attic during the summer months.

The need for attic ventilation varies with the local climate and the construction of your home. Homes in dry, windy areas will need less attic ventilation than homes in calm, humid areas. Attics under dark-colored roofs need better ventilation than attics under light-colored roofs.

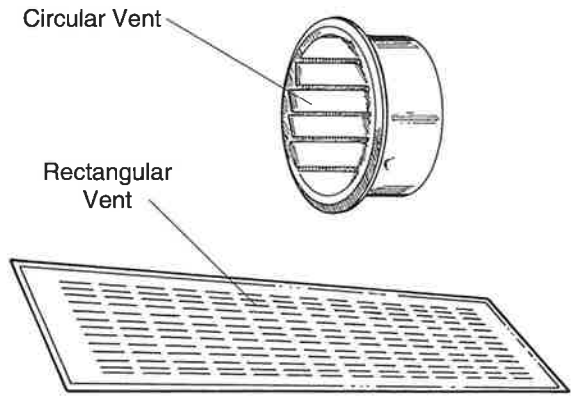
Water condenses out of warm, moist air as the temperature cools. Much of the mois-



3-5 Air Flow for Soffit Ventilation - *Make sure your insulation does not block the air passage between the soffit and the attic.*

ture that accumulates in attics during cold weather comes from the living spaces below, as warm air rises into the attic through unsealed areas (*see Section 2.3, Reducing Air Leakage*). Sealing the leaks in the ceilings is more effective than increasing the attic ventilation.

Condensation in summer may be caused by cool air leaking from cooling system ductwork. Attic ventilation is needed in even the driest climates to remove dampness caused by roof leaks or condensation.

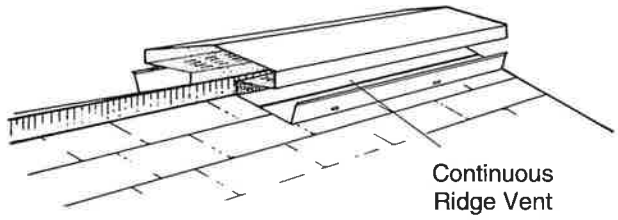


3-6 Soffit Vents *- Circular vents fit into 2- to 4-inch holes placed close together. Rectangular vents provide more free-vent area and can be spaced farther apart.*

Attic ventilation also serves an important cooling function. The outside temperature and the amount of attic insulation determine how much heat flows into the home through the ceiling. The temperature of your ceiling influences both comfort and cooling costs. The greater the airflow through the attic, the cooler the attic and the indoor ceilings will be. **In some cases, effective attic ventilation can save 10 percent or more on cooling costs.**

There are three primary ways to cool your attic: install a reflective roof color (*see Section 2.4.1, Roof and Wall Reflectivity*); use radiant barriers (*see Section 2.4.2, Radiant Barriers*); and provide ample ventilation.

Good attic ventilation allows an even flow of air through all parts of the attic. Most attics do not have an evenly distributed flow because they are vented by a few randomly spaced roof vents. This type of attic venting tends to ventilate some areas and leave other areas unventilated. A better ventilating scheme uses ample soffit vents and a continuous ridge vent (*see figures* **3-4** *and* **3-7**). Static vents, as shown in figure **3-3**, should be located higher on the leeward side of the roof as exhaust vents, or lower on the windward side of the roof as intakes. The wind provides some pressure and suction to move ventilating air through the attic.

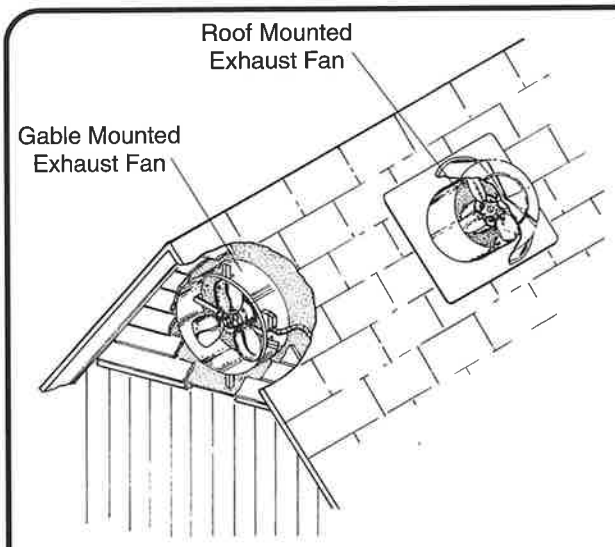


3-7 Continuous Ridge Vent *- This continuous high vent allows the hottest air to flow out of the attic. Installation: cut the roofing back about 2 inches on each side of the peak. Then cut and remove 1 to 2 inches of roof decking on each side of the peak. Install the ridge vent.*

Attic insulation near the eaves must leave a path for ventilating air that comes through the soffit vents into the attic (*see figure* **3-5**). Existing insulation can be packed down at the eaves to facilitate the flow of air through the attic.

To determine your attic ventilation

needs, calculate the square footage of the attic. You will need from 1/2 to 2 square inches of "net free" area per square foot of attic. Cool, dry, windy climates need less ventilation while hot, sunny, humid climates need more. Homes with whole-house fans or evaporative coolers with up-ducts need the most attic ventilation and represent the higher end of the above recommendations (*see Section 4.2.1, Sizing and Selection*).

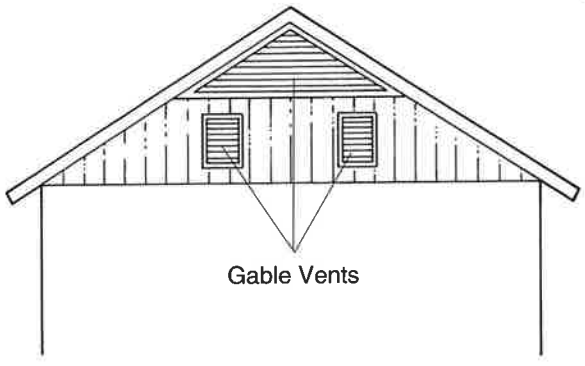


3-8 Power Attic Ventilator *- Power exhaust fans mounted on the roof or in an attic gable are expensive, but effective, ventilators. Use power ventilators as a last resort when other venting methods won't work.*

Most vents are marked with their "net free" area. This figure takes into account the resistance offered by screening, louvers, and weather coverings. Installing insect screen on a vent reduces its effective area or net free area in half. Determine the total number of vents needed, and install half of them as lower intake vents and half as higher exhaust vents.

Power attic ventilators are exhaust fans controlled by thermostats that turn on at a set temperature between 110°F and 140°F. They are an expensive but effective venting strategy used as a last resort for attics under dark-colored roofs, and for attics with moisture problems.

Place a power attic ventilator near the top of the roof on the leeward side of the house (facing away from the prevailing winds). Or, mount the fan in the leeward gable (*see figure* **3-8**). Provide at least one square foot of net free intake area for every 300 cfm of fan capacity. The American Ventilation Association recommends 1 cfm per square foot of attic floor space. Therefore, if your attic is 1200 square feet, you'll need a 1200 cfm fan, with 4 square feet of net free intake area. Power attic ventilators are rated at between 700 and 2000 cfm.

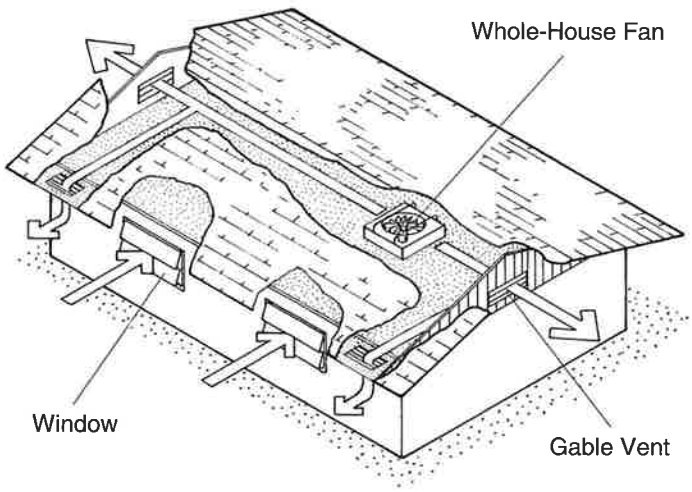


3-9 Gable Vents *- Large gable vents are useful for releasing exhaust air from whole-house fans and evaporative coolers that use up-ducts. See Sections 3.4 and 4.2.1.*

3.4 The Whole-House Fan

A whole-house fan can substitute for air conditioning during spring, fall, and mild weather (*see figures* **3-10** *and* **3-11**). Whole-house fans combined with ceiling fans and portable fans provide acceptable summer comfort for many families, even in hot weather. They can reduce indoor temperatures 3 to 8 degrees, depending on outdoor temperatures. **You can expect a 15 to 55 percent reduction in air conditioning costs through the prudent use of a whole-house fan.**

The whole-house fan pulls air in from open windows and exhausts it through the attic and roof. It provides good attic ventilation in addition to whole-house ventilation (*see figure* **3-10**). You can regulate cooling by simply closing windows in the unoccupied areas and opening windows wide in occupied areas. Most people cool the bedrooms at night and the living areas during the daytime.



3-10 Whole-House Fan *- These fans exhaust air through the attic and attic vents, and cooler air flows through open windows.*

Whole-house fans should provide homes with 15 to 40 air changes per hour. The rate of air change depends on your climate and how much you depend on the whole-house fan for cooling. Cooler, shadier areas don't require as much ventilation as warmer, sunnier ones. Homes entirely dependent on whole-house fans require a higher ventilation rate.

Whole-house fans range in diameter from 24 inches to 42 inches, with capacities ranging from 3,000 to 10,000 cubic feet per minute (cfm). The capacity of the fan in cfm is rated for two different conditions: 1) free air; and 2) air constricted by 1 inch of static pressure. The second condition is closer to the actual operating conditions of the fan in a home, and the cfm rating at 1 inch of static pressure may still be 10 to 30 percent higher than the actual volume of air moved by the installed whole-house fan. This means you should probably install a fan with a greater capacity than the sizing recommendations that follow would recommend.

Whole-house fans require 2 to 4 times the normal area of attic vent openings (*see figure* **3-9**). Install a minimum of 1 square foot of net free area for every 750 cfm of fan capacity. However, more vent area is better for optimal whole-house fan performance because the air flow is less restricted.

The net free area of most manufactured vents is marked somewhere on the vent. (The net free area is about half of the actual area of the vent and accounts for resistance caused by screens and louvers.)

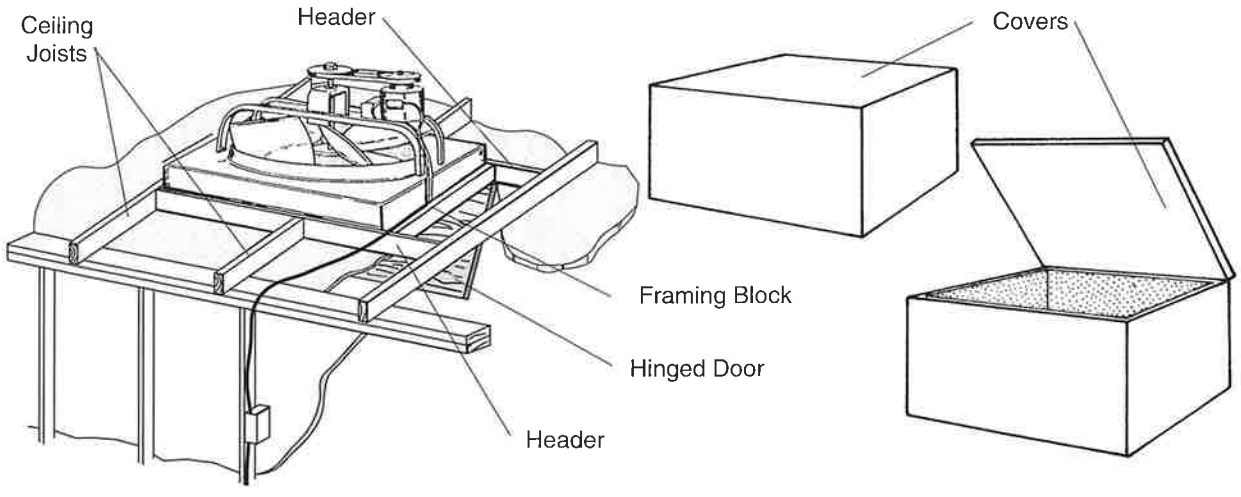
To determine the suitable size of a whole-house fan in cubic feet per minute, first determine the volume of your home in cubic feet. To calculate volume, multiply the square footage of the floor area in your home that you want to cool by the height from floor to ceiling. Take that volume and multiply by 15 to 40 air changes per hour, depending on how much ventilation you want. Then, divide by 60 minutes to get cubic feet per minute of capacity for the whole-house fan (*see formula below*).

$$\text{Whole-House Fan Capacity (cfm)} = \frac{\text{Floor Area (sq.ft.)} \times \text{Ceiling Height (ft.)} \times \text{15-40 Air Changes/Hour}}{\text{60 Minutes/Hour}}$$

A whole-house fan can be noisy. Install the fan on solid supports with rubber or felt gaskets to dampen noise from vibration. A large-capacity fan running at a low speed makes less noise than a small fan operating at high speed. Larger fans also cool the home and attic quickly in the evenings and mornings, when the cooler outdoor air can remove heat that accumulated during the hotter parts of the day.

A 2- or 3-speed fan control is a nice option for a whole-house fan. You can ventilate the entire house quickly at high speed, or just maintain gentle air circulation with less noise.

Follow the manufacturer's instructions for installing a whole-house fan. Most fans provide a template to outline the hole to be cut in the ceiling. One side of that rectangular hole should run along the inside of a ceiling joist (or bottom truss chord). Before you start cutting be certain where the edge of the joist is and check for wires and other obstacles. The distance between

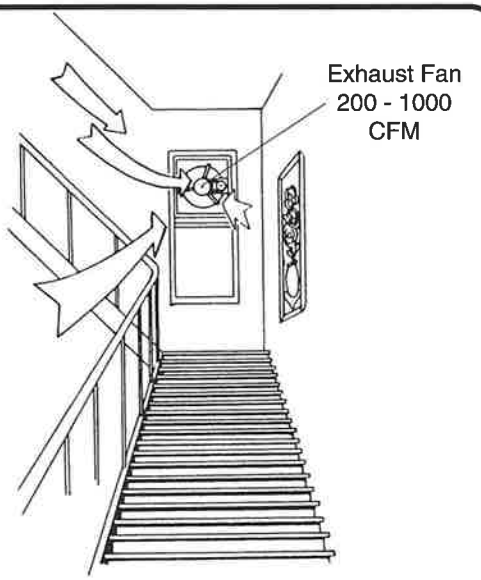


3-11 Installation of a Whole-House Fan - *This view of a whole-house fan from the attic shows how it is installed. Any one of the three covers shown on the drawings will seal the fan off in the winter.*

joists is usually less than the size of the fan, so you'll have to cut through at least one joist to create a hole large enough for the fan. Build a support consisting of two new headers and a framing piece between them (*see figure* **3-11**). Fasten new framing members securely with screws and adhesive to strengthen the opening and reduce vibration.

Connect the fan to its own 115-volt circuit. This prevents overloading an already busy circuit, and allows you to turn off the breaker in the winter months and prevent someone from accidentally turning the covered fan on and burning out the motor.

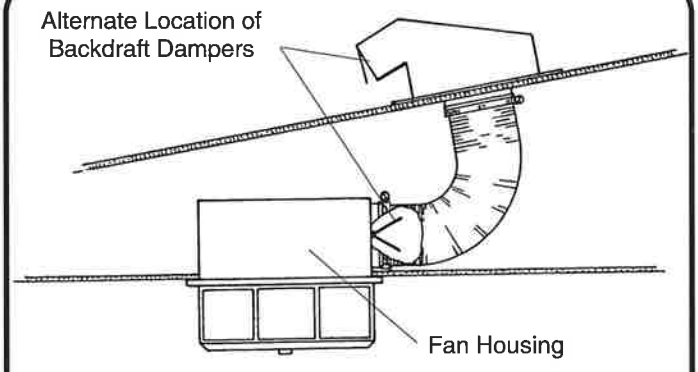
Some fans come with a tight-sealing winter cover (*see figure* **3-11**). If your fan doesn't have such a cover, or if your attic access doesn't allow you to cover the fan easily, then you can fabricate a cover for the grille on the ceiling. A seasonal cover held in place with rotating clips or spring clips and sealed with foam tape works well. If you switch between air conditioning and cooling with a whole-house fan as the summer weather changes, build a tightly-sealed, hinged door for the fan opening that is easy to open and close when switching cooling methods.



***3-12 Window Fan** - A powerful window exhaust fan on the leeward side of the house can ventilate part of a large house or all of a smaller house.*

3.5 Smaller Ventilation Fans

Window fans are best used in windows facing the prevailing wind or away from it to provide cross ventilation (*see figure* **3-12**). Window fans can augment any breeze or create a breeze when the air is still. If the wind direction changes in your area, use reversible type window fans so you can either pull air into the home or push air out, depending on which way the wind is blowing. Experiment with positioning the fans in different windows to see which arrangement works best. **You can save up to 50 percent on cooling costs by ventilating with fans rather than running air conditioners during mild weather and at night.**



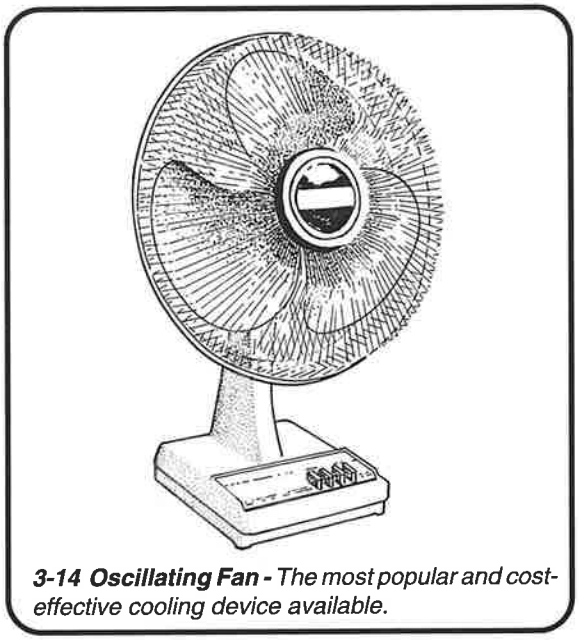
***3-13 Exhaust Fan Backdraft Dampers** - Kitchens and bathrooms need exhaust fans to remove heat and moisture at their source. Exhaust fans must have backdraft dampers to limit air leakage from outdoors.*

Use exhaust fans in the kitchen and bath to remove heat and humidity when

cooking and bathing. In humid climates, it makes sense to run the exhaust fan until windows and mirrors are clear of steam. Use a half-hour timer to control the fan, which helps keep the bathroom dry and mold-free. A newer type of control called a dehumidistat can control exhaust fans by the level of humidity in the air. These controls can be very effective at holding humidity at a reasonable level except at times when the humidity outdoors is higher than the setting on the dehumidistat.

New exhaust fans are rated for noise. You'll likely use a quiet fan more than a noisy one, so look for one that produces less than 3 sones of noise. Use larger-size fans (80-100 cfm for a bathroom, 160-200 cfm for a kitchen) if the outlet is connected to flexible duct, because the flexible duct resists air flow more than the fan ratings indicate. It's better to use galvanized steel duct sealed at the joints.

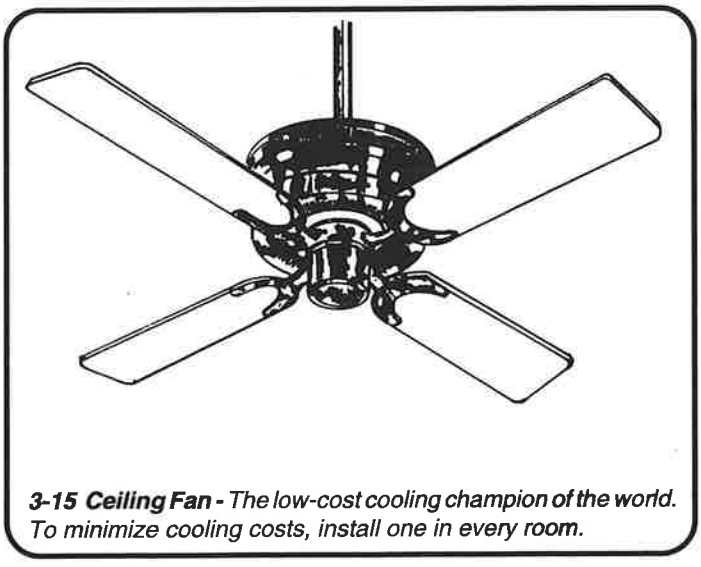
Exhaust fans must vent outdoors. Venting them into the attic can cause moisture problems. Another common problem is air leakage around the fan housing. If the housing is not sealed tightly to the ceiling of the room, then hot, humid air from the attic can leak into your home through the gaps around the housing. Be certain the fan has a backdraft damper in one of the two locations shown in figure 3-13.



***3-14 Oscillating Fan** - The most popular and cost-effective cooling device available.*

3.6 Indoor Air Circulation

Air circulating fans are very effective and should be used with air conditioners, evaporative coolers, whole-house fans, or by themselves. Circulating fans save cooling energy by increasing air movement over the skin to help you feel cooler. Ceiling fans and various types of portable fans provide more comfort at less cost than any other electrically powered cooling strategy (*see figures* ***3-14*** *and* ***3-15***). There are many options: small personal fans can sit on tabletops, or heavier units sit on the floor or on metal stands with wheels.



***3-15 Ceiling Fan** - The low-cost cooling champion of the world. To minimize cooling costs, install one in every room.*

Air circulating fans may allow about a 4 degree rise in the thermostat setting

with no decrease in comfort. Savings in cooling costs range from 15 to 40 percent. Scientific tests by P.O. Fanger in 1970 indicated that people feel just as comfortable in gently moving air (1.7 miles per hour) at 82°F as they feel in calm air at 78°F. The same tests showed that a large majority of people said they felt comfortable at a temperature of 82° and a relative humidity of 100 percent—when the air speed around them was 3.4 miles per hour. To take full advantage of this "wind chill effect," install ceiling fans and portable fans in every room and turn up the speed until paper begins to rustle on tabletops. Air speed should be as high as possible without creating a nuisance.

Ceiling fans are the most effective fans for large rooms. Ceiling fans range from 36 to 52 inches in diameter. A 36-inch fan services a room 12 feet by 12 feet or less. Use a 42- or 48-inch fan for rooms up to 14 feet by 18 feet. Larger rooms require a 52-inch fan, or multiple fans.

Ceiling fans produce high air speeds with less noise than oscillating fans or box fans. High quality ceiling fans are generally more effective and quieter than cheaper ones. **Ceiling fans are a key element to providing low-cost comfort in your home.** Consider installing one in every room.

Portable circulating fans provide local air circulation and cooling in areas where people spend most of their time. Circulating fans only help in rooms that are occupied. Turn fans off in unoccupied areas.

Notes: