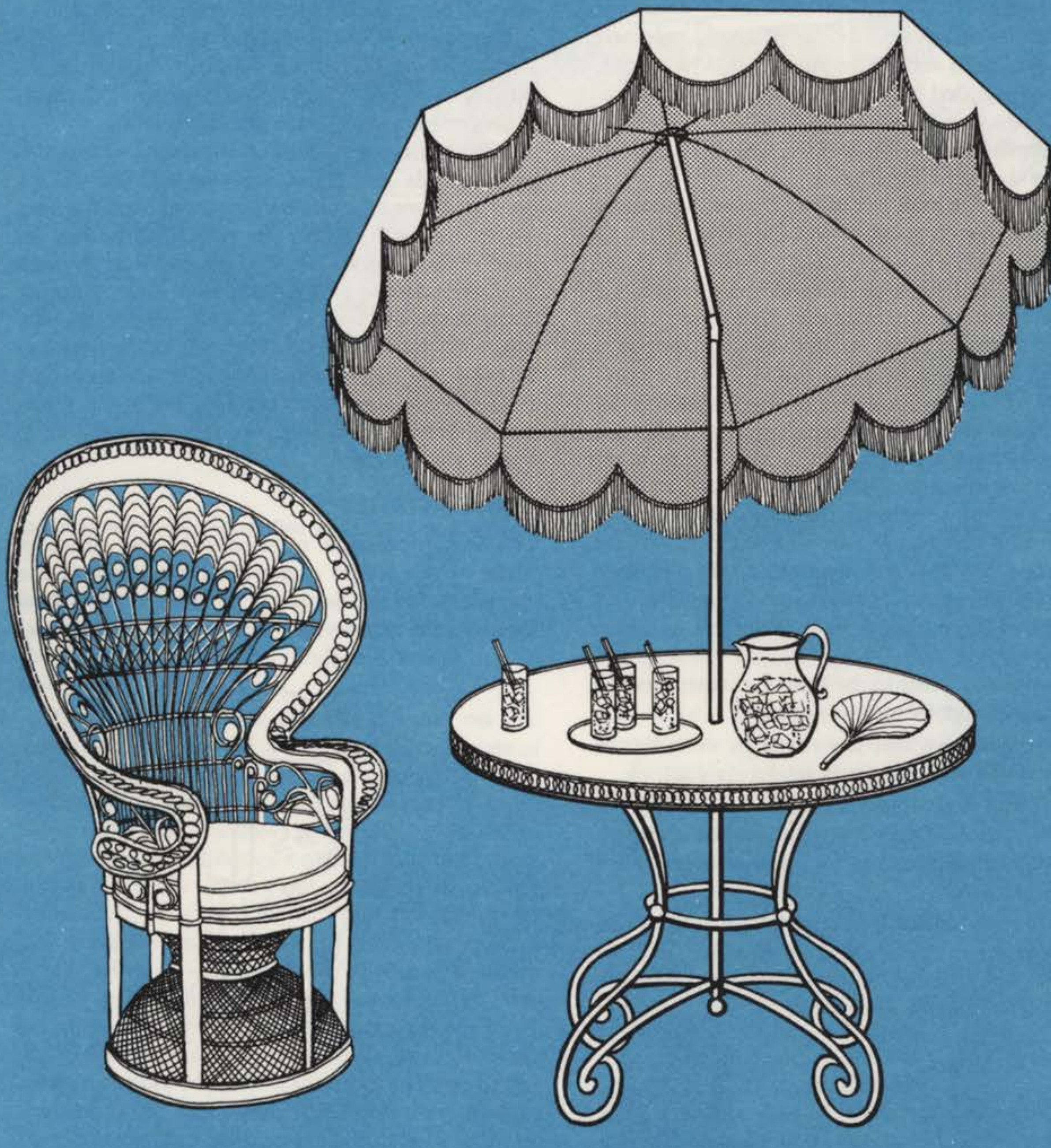
University of Illinois at Urbana-Champaign
Small Homes Council-Building Research Council

COUNCIL NOTES



G6.0 SUMMER COMFORT

Summer Comfort G6.0 Volume 4 Number 1 Summer, 1980 Twenty-five cents

A comfortable home during the hot summer months is essential for the enjoyment of work, relaxation, and sleep. Generally, temperatures of 75° to 80°F and relative humidities of less than 60% are desirable.

Under summer conditions, a house can become a "heat trap." Like an automobile which is closed but exposed to the summer sun, the house absorbs heat through windows, doors, walls, and roof.

Heat from occupants, appliances, electric lights, and bath water also adds to this heat load. This accumulated heat results in indoor temperatures which can be uncomfortable for occupants long after the sun has set and the outdoor temperature has dropped.

Keeping the heat out of the house is the most important step toward achieving summer comfort. If the sun's rays can be kept off the walls, glass areas, and the roof, and if the hot outdoor air can be kept from penetrating the house, the indoor temperature can be more easily controlled. Comfort is dependent upon the ability to control the **rate of temperature rise** in the house during the day. An uninsulated building, such as a tin shed, may have a temperature rise of 5°F or more per hour, while a well-insulated house has been shown to have a temperature rise as low as ¾°F per hour. If the house can be cooled to 68°F at night, and has a ¾°F temperature rise per hour from 6 a.m. to 6 p.m., the indoor temperature will be only 77°F, which falls within the comfort range.

If heat does get into the house, the problem of summer comfort becomes one of:

- removing the hot air through ventilation when the outdoor air is relatively cool, or
- reducing the indoor temperature by using a mechanical cooling system (air conditioner), which can also reduce the amount of moisture in the air, or
- reducing indoor temperature using an evaporative cooler. This is effective only in areas of low relative humidity, and does raise the humidity in the house.

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This publication describes a number of design and construction features which are helpful in reducing the amount of outdoor heat entering the house, and devices and techniques for cooling which require less energy than mechanical refrigeration for air conditioning.

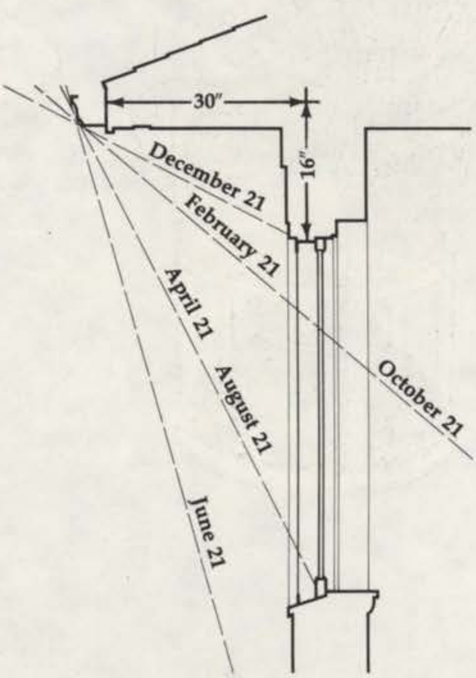
SOLAR ORIENTATION

Houses can be oriented and designed to exclude the sun from the house during the hottest months of the summer, and yet allow the sun to enter the house during the winter when the heat from the sun is desirable. See Council Note C3.2, *Solar Orientation*, for an extended discussion.

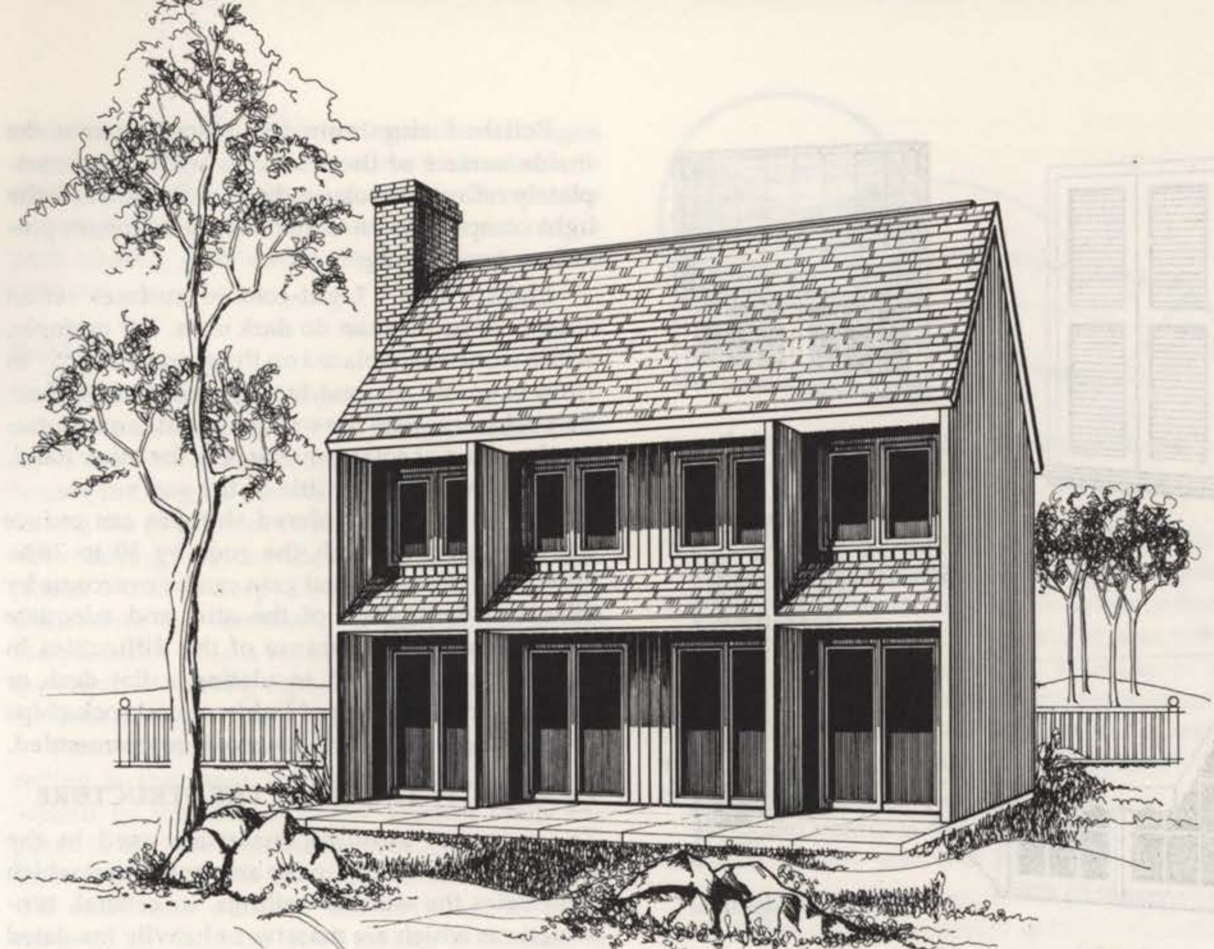
From the standpoint of summer comfort, the major walls and glass areas should be on the south, where they can be protected from the sun, or on the north, where the effects of the sun are negligible. The wall and glass areas on the east and west should be kept at a minimum, because these walls are harder to protect due to the low angle of the sun in the early morning and late afternoon. Heat gains through windows are many times larger than through brick and frame walls; therefore it is particularly important to shade glass areas.

SUN CONTROLS

The sun protection necessary for the different walls of the house depend on the angle of the sun's rays in the summer. If not protected from the sun, the temperature of the outside wall sur-



Shading of south windows at 39° latitude (Colorado Springs, CO; Kansas City, MO; Cincinnati, OH, Washington, D.C.)



Extended end walls, vertical fins, and overhangs at all levels can provide appropriate shading for south-facing windows.

face may reach 135°F; when shaded, the surface temperature is only slightly higher than that of the outdoor air. Various kinds of controls can be used:

Overhangs. Since the sun shines on the south side of the house most of the day, the use of shading devices to protect the southern exposure is desirable. Roof overhangs or other permanent projections over windows and sliding glass doors are particularly effective on the south wall. East and west walls cannot be protected from the direct rays of the sun by overhangs because of the low sun angle in the morning and evening.

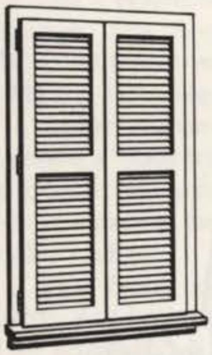
Overhangs – extensions of the roof – are simple to incorporate into the house design. The recommended overhang for latitudes from 30° to 50° is as indicated. To prevent the rays of the early morning or late afternoon sun from passing under the end of the roof overhang, the east-west walls may be extended beyond the south wall as far as the overhang.

Tall plantings. Trees are particularly good as shade for east and west walls and the roof. When planting, consider the ultimate height and size of trees, and study the desired shade patterns. Use deciduous trees, which lose their leaves and allow the sun to reach the house during the winter.

Free-standing vertical sunshades. Walls or fences are excellent protection against low sun on east or west walls. They are seldom high enough to shade walls during the middle of the day. They may be used with tall plantings. Open or louvered fences do not block summer breezes.

Exterior window louvers or venetian blinds. When cream-colored louvers or venetian blinds with a slat angle of 45° are used on the outside of

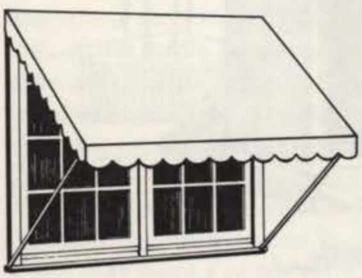
Fences can provide both privacy and sunshade to east and west windows and doors.



Shutters

Roll-up blinds

Louvered sunshade



Awning

the house, they reduce the heat gain from the sun by 70%. They are only 40% effective when used on the inside of the house. Because louvers or blinds change the appearance of the house, they should be designed to complement the exterior styling.

Awnings. Canvas awnings reduce the solar heat gain 65 to 75%. Metal awnings with ventilated slats are available, mostly of the permanently mounted type. Permanent awnings will block the winter sun and may not fit in with the appearance of the house. Awnings can be effective on east, south, and west windows during most of the day.

Louvered insect screens. When used on south windows, louvered screens can reduce the solar heat gain about 80%. They are only about 25 to 55% effective on the east and west since the sun's rays are low and pass between the louvers.

Reflective films. Semi-transparent reflective films can be installed on the inside surface of windows to reflect part of the solar radiation. They cannot be readily removed to permit the sunlight to enter during the winter, but may be quite effective on east and west windows in reducing solar heat gain and glare. Windows must be washed with care, as the film is easily scratched.

Polished aluminum foil placed against the inside surface of the windows will almost completely reflect the solar radiation. It will block the light completely, so the windows no longer provide room lighting.

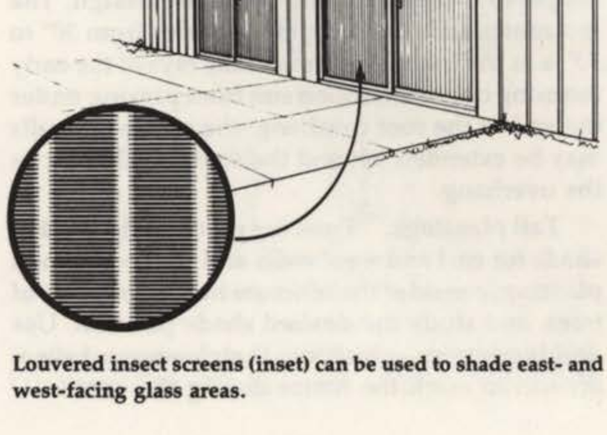
Light colors. Light-colored surfaces reflect solar heat better than do dark ones. For example, white stone chips placed on the ground directly in front of south- or west-facing glass areas will reflect solar rays into the windows and can counteract the effect of solar controls. On the other hand, a green lawn reflects little of the sun's rays.

The use of light-colored shingles can reduce the heat gain through the roof by 10 to 20%. However, this solar heat gain can be overcome by adequate ventilation of the attic and adequate ceiling insulation. Because of the difficulties in properly venting and insulating a flat deck or built-up roof, the use of light-colored rock chips or gravel on top of the black roof is recommended.

HEAT FLOW THROUGH THE STRUCTURE

The types of building materials used in the house are also a factor in the amount of heat which penetrates the walls or ceilings. In general, constructions which are massive or heavily insulated are slower to heat and slower to cool. This applies to masonry walls, heavy roof decks, and extra-thick insulation.

Sometimes heat accumulates in the building materials during the day and is released to the inside of the house in the evening, thus delaying the cooling of the house. However, the benefit of reducing the maximum flow of heat, making it



Louvered insect screens (inset) can be used to shade east- and west-facing glass areas.

possible to use a smaller cooling unit, outweighs the disadvantage of having some heat release to the house in the late evening. In general, massive or heavily insulated walls and ceilings reduce the peak cooling load and extend it later into the evening.

Insulation

Insulation, in addition to reducing heat loss in the winter, is an important aid to summer comfort. It slows the flow of heat from the outdoors into the house, helping to maintain lower temperatures during the day. For example, for each 1000 square feet of ceiling area, the addition of R-19 insulation (about 6 inches deep) to an uninsulated ceiling will reduce the summer heat gain about 26,000 Btu per hour. This is equivalent to a reduction in the required cooling capacity of a central air conditioner of more than 2 tons.

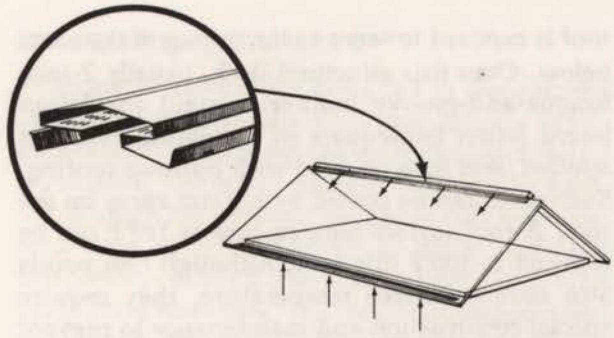
From the standpoint of summer comfort, the ceiling is the most important area to insulate. Second in importance is the exterior walls exposed to the sun. In areas north of 35° latitude, the amount of insulation adequate for winter heating will suffice for summer comfort also. In areas south of 35° latitude, R-19 ceiling insulation is recommended. Full-thickness insulation in the east and west walls will be especially helpful.

The difference in comfort is illustrated by the two examples shown for attic-ceiling construction. When an uninsulated ceiling is exposed to a hot attic, the ceiling temperature can go as high as 100°F in the late afternoon. When a ceiling is heated to this temperature, it transfers about the same amount of heat as that given off by a so-called "radiant ceiling panel" heating system in the winter. If R-19 ceiling insulation is added under the same conditions, the maximum ceiling surface temperature is reduced to about 80°F, only 2° warmer than the room-air temperature. Also, the maximum temperature is delayed more than an hour, so the maximum heat gain through the ceiling does not coincide with the peak cooling load from the windows.

Reducing temperatures below the roof

The accumulation of heat in the ceiling insulation can be reduced by ventilating the space between the roof and the insulation. The methods of ventilation include:

- Air movement due to convection (effective only on sloped roofs).
- Air movement due to wind pressure (as in areas of steady winds).
- Mechanical ventilation using attic fans and/or roof ventilators.



Ridge vents are an efficient way of providing attic ventilation when combined with soffit vents.

The Federal Housing Administration requires a minimum net free area of attic vents equal to 1/150 of the ceiling area if there is no vapor barrier in the ceiling and 1/300 of the ceiling area if there is a vapor barrier present. For a ceiling or attic floor area of 1000 square feet, this corresponds to net free areas of 6.67 and 3.33 square feet respectively. Half should be low or soffit vents and half high or ridge vents.

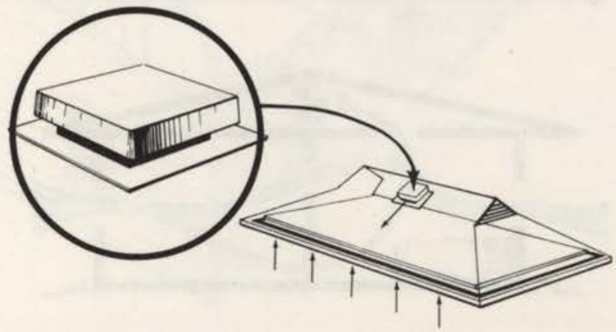
Ways to ventilate the space between the roof and ceiling vary with roof types.

Gable roofs. A screened soffit vent should be installed on the underside of the roof overhang and should extend the entire length of the overhang. Be sure that the attic insulation does not restrict the flow of outdoor air through the attic. The most effective outlet for heated attic air is a ridge vent, which should be designed to prevent the entry of insects, birds, rain, and blowing snow. Gable-end vents and high roof vents may be used if a ridge vent is not practical.

Hip roofs. Continuous soffit vents are necessary. The ridge vent may need to be supplemented or replaced by dormer louvers or roof vents.

Flat and shed roofs. Continuous screened vents at the ends of the joists are recommended. A continuous air space between the insulation and the roof deck must be provided.

Plank-type roofs. It is impossible to provide roof ventilation since the structural deck of the



Mushroom roof vents can be used in combination with soffit vents when ridge vents are not practical or desired.

roof is exposed to serve as the ceiling of the room below. Over this structural deck, usually 2-inch tongue-and-groove lumber, a rigid insulation board (often inadequate in insulating value) is applied, and then covered with built-up roofing. Such roofs can be cooled by a water spray on the roof. A roof surface temperature of 140°F can be reduced to 100°F this way. Although roof ponds also reduce surface temperature, they require special construction and maintenance to prevent water leakage, algae growth, and mosquito-breeding conditions.

VENTILATION OF ROOMS

Ventilation of rooms is desirable whenever odors from cooking, smoking, animals, etc., become noticable; moisture released from bathing, cooking, house plants, etc. becomes noticeable; the lack of air motion produces a feeling of "stuffiness"; or when excessive heat is released in one area, such as the kitchen or bath.

Natural ventilation can be provided by openable windows, especially those that are placed to take advantage of prevailing breezes. The most effective air movement is when the ventilation openings are on opposite walls and the air flows across the room within the height of human occupancy. In localities with constant winds, such as Hawaii, well-placed jalousie windows can provide acceptable indoor conditions without the use of mechanical refrigeration. The higher relative humidity can be partly offset by the cooling action of the air movement through the rooms.

Exhaust fans help to remove the heat and moisture from the bathroom and kitchen.

Night air cooling with fans

A house which is ventilated only by open windows, louvered openings, and doors on a calm summer night will not cool rapidly due to lack of air circulation. By operating either attic or window fans throughout the night, large quantities of cooler night air can be circulated through the house, lowering the indoor air temperature quickly. If the windows are closed early in the morning, with only enough openings for ordinary ventilation, the house can begin a hot day at a much lower temperature than if the house was still overheated from the previous day.

Night-air cooling can be made more efficient by using a fan to exhaust air from the house through the attic.

Night-air cooling can reduce the indoor temperature to within a few degrees above the outdoor temperature, and will usually be coolest just before sunrise. A thermostatic control on the fan will prevent overcooling if the outdoor temperature drops suddenly.

Night-air cooling has some disadvantages. Dust and pollen are likely to be brought into the house. If night-time humidity is high, considerable moisture will be brought into the house. Window openings in ground-floor rooms may be limited because of security requirements. However, positive stops for limiting the window opening to about six inches can be installed.

Attic fans. The size of the attic fan needed for night-air cooling depends on the volume of the house and the number of air changes desired. Where the night air temperatures do not drop much below 75°F, a large amount of air must be circulated. In the Gulf Coast areas, one air change per minute is recommended; in cooler regions, one air change each two minutes is suggested.

Approximate capacities of attic fans for various floor areas (assuming a standard 8-foot ceiling height) are listed as a guide for selecting a fan. Manufacturers' catalogs usually give the fan capacity and installation instructions.

In general, large, low-speed fans are quieter than small-diameter, high-speed units.

RECOMMENDED FAN CAPACITY

Floor area of house sq. ft.	For regions of cool nights cfm	For regions of warm nights cfm
800	3000	6500
1000	4000	8000
1200	5000	9500
1400	5500	11000
1600	6500	13000
1800	7000	14500

Capacities are for so-called "free air delivery." If obstructions or resistance to flow of air exist, such as louvers, screens, and ducts, the actual air delivery will be less than the "free air delivery."

Window fans. While a window fan is easier to install, it is limited in the area that it can cool. It is also likely to be noisier than an attic fan.

If installed in a hallway window, a fan can serve more than one room. If the fan is placed in a room window, the doors to that room will have to be left open, and all windows adjacent to the one in which the fan is installed must be kept closed to prevent "short circuiting" of the air.

Room-air fans. The old-fashioned ceiling fan (a large four- or six-bladed propellor fan operated at low speed) and floor fans have been revived as a low-cost approach to comfort cooling. In this case, no outdoor air is introduced and the cooling effect on the body is mainly by air motion. The fans also mix the cooler air from near the floor with the warmer air at body level. The body heat is transferred to the room air by forced convection, and the body is cooled by the evaporation of perspiration. This is a milder summer version of the "wind-chill effect" that can be so uncomfortable in the winter.

CENTRAL AIR CONDITIONING SYSTEMS

Where the desired comfort level cannot be obtained solely by house design and ventilation, the use of a mechanical air conditioning system is suggested. Insulation, attic ventilation, and shading of the glass and wall areas are, of course, necessary for the efficient and economical operation of any cooling system. With night-air cooling, it may be possible to reduce the number of hours that the air conditioning system operates during the day.

ROOM AIR CONDITIONERS

Window and through-the-wall air conditioning units can be used to cool small sections of a house. In many cases, they are mechanically more efficient than central units, and it is possible to cool only the area of the house being occupied. These units are often noisier than central systems.

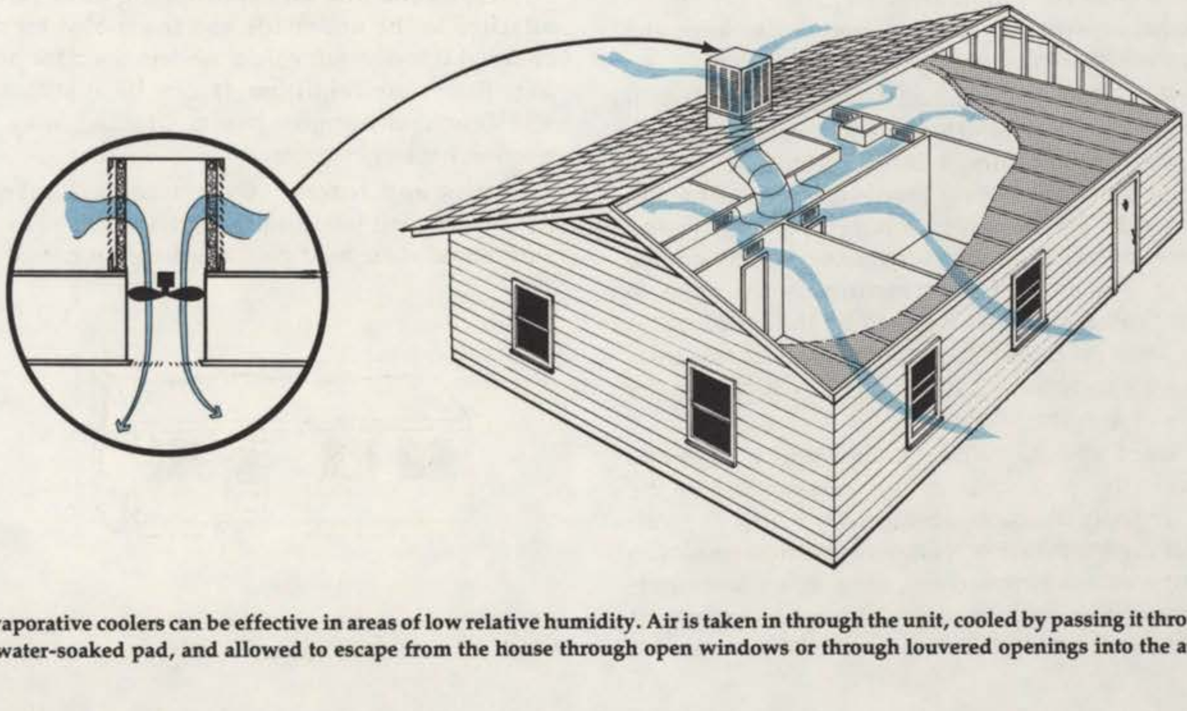
An extended discussion of both central and room air conditioning units is contained in Circular G6.1, *Cooling Systems for the Home*.

EVAPORATIVE COOLERS

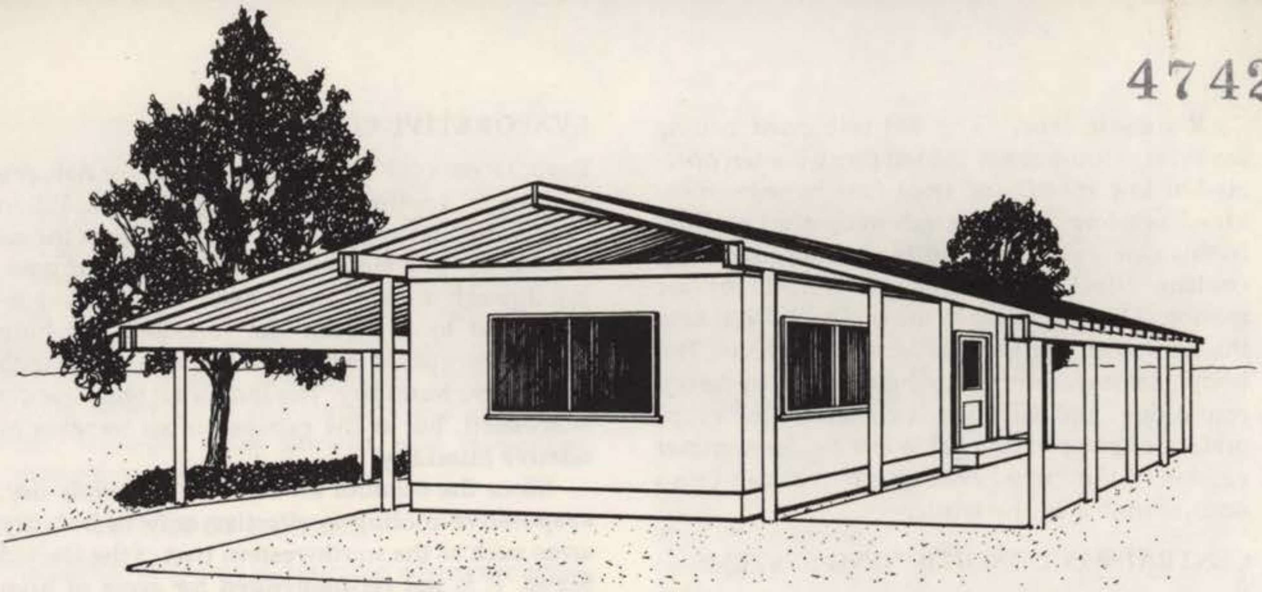
Evaporative coolers are designed to use nature's system of cooling air by evaporation. When evaporation takes place, the temperature of the air is reduced. The temperature of both the air passing through the unit and the water being evaporated tend to approach the so-called wet-bulb temperature of the outdoor air, which varies with the relative humidity. The indoor air temperature is reduced, but at the expense of an increase in relative humidity.

Since the outdoor air must be relatively dry, evaporative cooling is effective only in hot, dry areas such as the southwestern part of the United States. It is **not recommended** for areas of high humidity.

A typical evaporative cooler consists of a cabinet containing a filter pad and a fan. The fan draws **outdoor air** through the filter pad, which is kept moist with water. Through the evaporation of this water, the air in the cabinet is cooled. Means are provided to circulate the water to keep the pad moist and to replenish the water which is evaporated. The air is then discharged into the house and is allowed to escape through partly opened windows at the far end of the rooms. The room air is **not** recirculated because a large increase in relative humidity will result. The cooling effect is partly from the air motion resulting from the circulation of a large volume of air through the rooms. The cost of operation is low because the fan motor requires only a fraction of the power needed for the motors of a central air conditioning system using mechanical refrigeration equipment.



Evaporative coolers can be effective in areas of low relative humidity. Air is taken in through the unit, cooled by passing it through a water-soaked pad, and allowed to escape from the house through open windows or through louvered openings into the attic.



Mobile homes can be made more comfortable by shading the roof and sides with a pole-frame structure, which can also provide a covered patio and carport. The open structure allows heated air to escape from between the roof and the mobile home.

COOLING MOBILE HOMES

Many mobile homes are not shaded by trees and shrubbery to reduce the heat gain from the sun in the summer. Furthermore, the roof construction does not provide for a ventilated attic space, so that the ceiling can become a radiant heating panel during the summer. A number of suggestions are made that may be helpful in the special case of the mobile home, although they do have some application to conventional houses.

Orientation. The best orientation for a long, rectangular building is to have the long side running east and west, so the largest wall areas face the north and the south. If the window areas on the long walls are not the same, it is best to have the largest window area facing south.

In order to reduce summer solar gain through the windows, a roof overhang, window overhangs, or awnings can be arranged to keep the summer sun out but let the winter sun in.

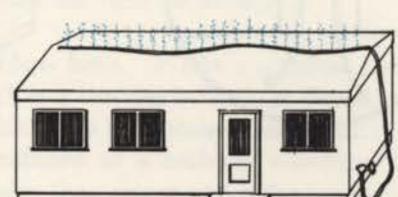
Roof shading. Some effective roof shading arrangements have been used in warmer areas of the country. A common desert system uses a pole-frame structure with a low-slope roof to form a sunshade for the mobile home plus a covered patio on one side and a covered carport on the other. The ends of the structure are left open so that heated air is not trapped by the building. A variation on this system uses a wood frame structure to support a canvas cover which can be removed in the winter.

Roof spray. When a fine spray of water covers the roof surface, the evaporation of the water cools the roof substantially below the outdoor air temperature. (The evaporation results in temperatures approaching the wet-bulb temperature of the outdoor air, which is always cooler than the dry-bulb temperature of the air except at 100% relative humidity.) The water can be applied by a hose that has a series of needle-sized holes that produce a fine spray. The ideal spray consists of a unit which will cover the entire roof with a fine spray without having surplus water running off the roof. If the spray is greater than desired, it can be operated intermittently. The spray should be turned off after sundown.

Window fan. A single window fan of substantial size can be successfully used in a mobile home. The fan can be located at one end of the home, preferably near the kitchen, to blow air out. The air enters an open window at the other end of the home so that the entire space can be ventilated with the same air stream.

Mechanical refrigeration. In some mobile homes, mechanical air conditioning units can be attached to the underside and the cooled air discharged into the same duct system used for heating. Room air conditioners can be installed in windows, although special bracing may be needed for larger units.

Patios and fences. By providing a covered patio and a tall fence on the sides exposed to the sun, some solar heat gain can be eliminated.



A fine water spray on the roof of a mobile home can help keep it cool.