CIRCULAR SERIES

INDEX NUMBER G6.0

SUMMER COMFORT

ISSUED BY THE SMALL HOMES COUNCIL

UNIVERSITY OF ILLINOIS BULLETIN

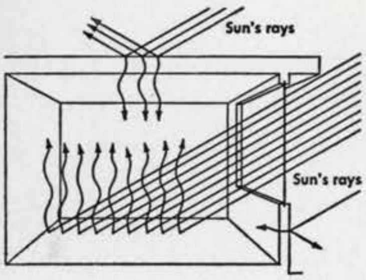
VOLUME 61, NUMBER 10; SEPTEMBER, 1963. Published nine times each month by the University of Illinois. Entered as second-class matter December 11, 1912, at the post office at Urbana, Illinois, under the Act of August 24, 1912. Office of Publication, 49 Administration Building (West), Urbana, Illinois.

This circular is one of a series on small homes. Other circulars are available for 15c each.
For information, write to Small Homes Council, Mumford House, University of Illinois, Urbana.

MATERIAL IN THIS CIRCULAR BY S. F. GILMAN, W. S. HARRIS, S. KONZO, R. W. ROOSE, W. F. STOECKER, DEPARTMENT OF MECHANICAL ENGINEERING; R. A. JONES, J. T. LENDRUM, SMALL HOMES COUNCIL

Editor: M. H. Kennedy
Illustrations: University Press Art Division

SUMMER COMFORT
SMALL HOMES COUNCIL G6.0



A house is a "heat trap."

SUMMER COMFORT

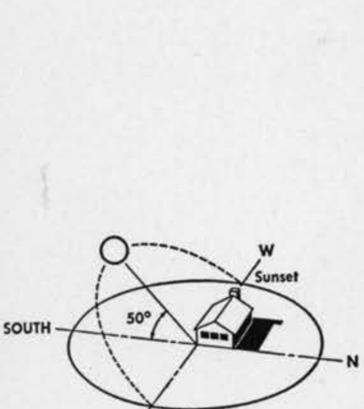
A comfortable home during the hot summer months is essential for the enjoyment of work, relaxation, and sleep. The drier the air, the higher can be the temperature without discomfort to occupants. Generally, temperatures of 75° to 80° F. and relative humidities of less than 60 per cent are desirable.

Any enclosure, such as a house, is a "heat trap." Like an automobile which is closed but is exposed to summer sun, a house accumulates 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 interior temperatures which can be uncomfortable for occupants long after the sun has set and outdoor air 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 held in check. Shading of the house and the use of other sun controls (roof overhangs, sun screens, louvers) are the principal means of protecting the house from the sun's rays. Insulating the walls and the roof helps to retard the flow of heat from the sun and the hot outdoor air. The choice of building materials is also a factor affecting indoor temperatures.

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 of reducing the indoor temperature by means of an air-conditioning system or an evaporative cooler. An air-conditioning system can also reduce the amount of moisture in the air.

This circular describes 1) design and construction features which are helpful in reducing the amount of outdoor heat entering houses, and 2) mechanical devices which provide comfortable air conditions through the control of temperature, humidity, and air motion.



Position of the sun at noon on March 21 and on September 21 in a latitude of 40° N. results in a 50° angle.

THE SUN AND THE HOUSE

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.

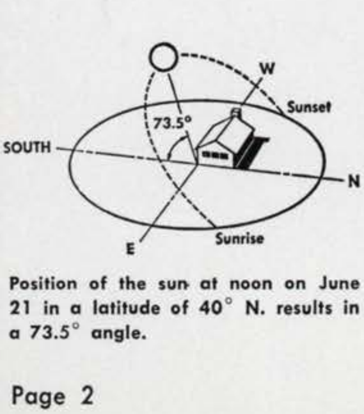
From the standpoint of summer comfort, the major walls and glass areas should be on the south where they can be protected from the sun or on the north where the effects of the sun are negligible. The walls and glass areas should be kept at a minimum on the east and on the west since these walls are more difficult to protect due to the low angle of the sun in the early morning and late afternoon.

Devices to shield the house from the sun should be designed into the structure and the lot in the early planning stages. Controls on the outside of the house keep the sun from striking the windows and walls and, thus, keep heat out of the house. They are, therefore, more effective than window shades and venetian blinds on the inside of the windows since such shades and blinds reflect the sun's rays only after they have entered the house. For example, when used on the outside of the house, light-colored venetian blinds with a slat setting of 45 degrees are 70 percent effective in reducing heat load from the sun; when used on the inside of the house, they are only 40 per cent effective.

In developing a house plan, take care not to put a paved terrace, driveway or other similar surface directly in front of south- or west-facing glass areas. The reflection of heat rays can counteract the effect of controls.

While sun controls are primarily designed to keep the sun's rays away from glass, which transmits heat readily, they also shield exterior walls effectively. If not protected from the sun, outside wall surface temperatures may reach as high as 135° F.; when protected, the temperatures are only slightly higher than those of the surrounding air.

Without shade from trees or buildings, the temperature on the exterior roof surfaces may reach 140° even though the outdoor temperature is below 100° F.



Position of the sun at noon on June 21 in a latitude of 40° N. results in a 73.5° angle.

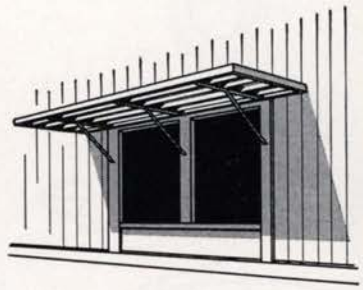
SUN CONTROLS

The sun protection necessary for the different walls depends on the angle of the sun's rays in the summer. Various kinds of controls can be used.

Overhangs: Since the sun shines on the south wall of the house most of the day, use of shading devices to protect southern exposures is very desirable. Because of the path of the sun in the summer, roof overhangs or other permanent projections over windows are particularly effective for the south wall. East and west walls cannot be successfully protected from the sun's direct rays solely by overhangs because of the low angle of the sun.

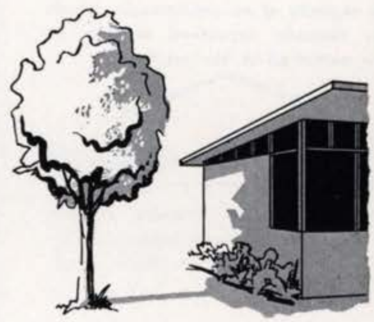
Overhangs — extensions of the roof proper — are simple to incorporate into the house design. The amount of the overhang to protect a south-facing window from the sun depends on 1) the latitude in which the dwelling is located; 2) the height of the window; and 3) the calendar period during which protection is desired. (See chart below.)

To prevent the rays of the early morning and late afternoon sun from passing under the end of the roof overhang, the east and west walls of the house should be extended beyond the south wall as far as the overhang.



Horizontal projections from the house effectively shield south windows from the sun's rays.

Trees and Other Tall Plantings (protective shrubbery): Trees are particularly good as shade for east and west walls, and the roof. When planting, consider ultimate height and size of trees, and study desired shade patterns. (See Small Homes Council circular B3.0 — "Land Design.") Use deciduous trees as they lose their leaves and allow the sun to reach the house in winter.

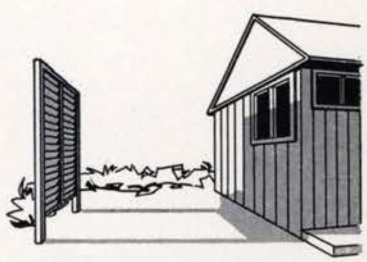


Trees are especially recommended to shade east and west walls and the roof.

Free-standing Vertical Sunshades (wall or fence): These are excellent against low sun (east and west walls); they are seldom high enough to shade walls during the middle of the day. Use with tall plantings. Louvered or open types do not block breeze.

Exterior Window Louvers and Venetian Blinds (adjustable): Cream-colored venetian blinds with a slat setting of 45 degrees, as pointed out, are 70 per cent effective in reducing load from the sun. Because louvers and blinds modify the appearance of the house, they should be designed to fit in with exterior appearance.

Awnings: Canvas awnings are from 65 to 75 per cent effective in reducing the heat load. They can be used successfully on east, south and west walls during most of the day.



Fences, walls, and tall shrubbery are good protection for east and west walls when the sun is low.

Louver-type Insect Screens for Windows: When used on the south, these are about 80 per cent effective in reducing the heat load. They are only 25 to 55 per cent effective on the east and west since the sun rays are low and pass between the slats.

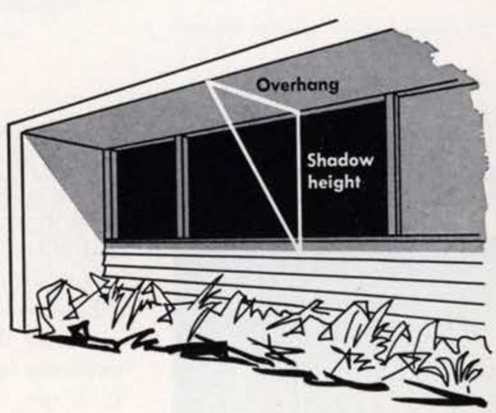
Light Colors: Light-colored surfaces reflect solar heat better than do dark ones. However, the effect of color on design cooling load is insignificant except in the case of roofs. The use of light-colored shingles reduces the heat gain through the roof by 10 to 20 per cent. Because of the relatively high heat gain through roofs, light-colored shingles on a pitched roof or light-colored rock chips or gravel or slag on a flat deck or built-up roof are recommended.

AMOUNT OF OVERHANG = FACTOR × SHADOW HEIGHT

To find the amount of roof overhang needed to cast the height of shadow desired on a wall or window:

1. **Determine the latitude in which you live.**
2. **Select the appropriate factor from the chart below.**
3. **Determine the height of shadow desired on the window and wall.**
4. **Multiply the factor by the desired shadow height.**

LATITUDE	25°	30°	35°	40°	45°	50°
FACTOR (for April 1-Sept. 11)	.37	.48	.59	.71	.85	1.02



BUILDING MATERIALS AND HEAT FLOW

The types of building materials used in the house are also a factor in the amount of heat which penetrates the walls.* Heat gains through windows are many times larger than through brick and frame walls; hence, it is important to shade glass areas. (Heat-retarding glass is of most value when the glass cannot be shaded.)

Sometimes heat accumulates in the building materials during the day and is released to the rooms in the evening, thus delaying the cooling of the house. This storage of heat is roughly proportional to the weight of the material used; therefore, the use of light-weight materials will lessen the heat storage.

Insulation

Insulation, in addition to reducing heat loss in winter, is an important aid to summer comfort. It slows up the flow of heat from the outdoors into the house, thus contributing to lower temperatures within the house. (See Small Homes Council Circular F6.0, "Insulation," for types of insulation.)

From the standpoint of summer comfort, the ceiling is the most important area to be insulated. Second in importance are the exterior walls that are exposed to the sun.

The amount of insulation needed depends 1) on the maximum temperatures, and 2) on the heat-resistant qualities of the wall or ceiling materials. In areas north of 35° latitude, the amount of insulation for winter heating will generally be adequate for summer comfort also.

Reducing Temperatures Below Roof

The accumulation of heat in insulating material in the ceiling can be reduced by ventilating the space beneath the roof. Methods of ventilation are by:

- Air movement due to the tendency for warm air to rise (effective on sloped roofs only).
- Air movement due to wind pressures.
- Mechanical ventilation by means of attic fans and roof ventilators.

Ways to ventilate the space beneath the roof vary with roof types.

Gable: Large louvers placed in the gable-ends allow easy passage of air through the attic space. By adding soffit ventilators, the effectiveness of ventilation can be increased. If gable roofs are excessively long, ridge ventilators are advantageous.

Hip: Continuous soffit ventilators are necessary. Additional ventilators near the ridge of the roof, such as dormer louvers or chimney vents, are desirable.

Flat and Shed: Continuous ventilators at the ends of the joist are recommended. Joist spaces must be continuous.

With **plank-type** roofs, it is impossible to provide roof ventilation since the structural deck of the roof is exposed to serve as the ceiling for the room below. Over this structural deck (usually made of 2-inch tongue-and-groove lumber) are applied rigid insulation and then a built-up roofing.

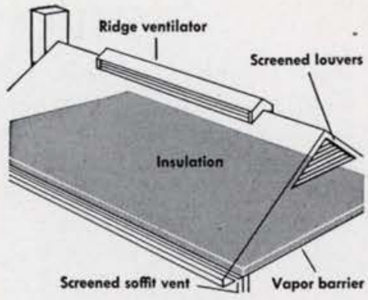
The plank-type roof is the most difficult to insulate and to cool. Such roofs can be cooled by pools of water or by a water spray on the roof deck. A roof surface temperature of 140° can be reduced to 100° F. this way.

* Relative amounts of heat transmitted per hour per square foot for different roof, wall, and window constructions are given here in Btu for comparison purposes. These are design values for an outdoor temperature of 95° F. at a latitude of 40°.

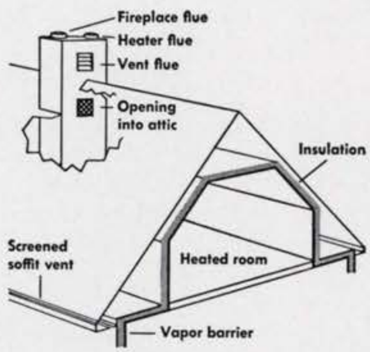
Ceilings Under Naturally Vented Attic or Vented Roof		Built-up Roof, No Ceiling	
Dark-color shingles, no insulation	10.0	Dark-color roof, no insulation	18.0
Light-color shingles, no insulation	8.0	Light-color roof, no insulation	14.0
Dark-color shingles, 4" insulation	2.0	Dark-color roof, 3" insulation	6.0
Light-color shingles, 4" insulation	1.0	Light-color roof, 3" insulation	5.0

Frame or Veneer on Frame Walls			
No insulation	6.0	2" insulation	3.0

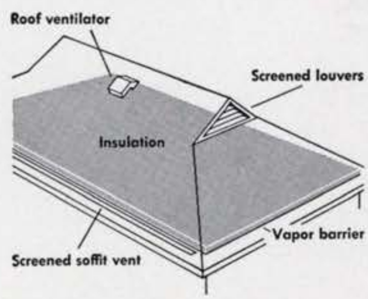
	Single-glazed Windows, Unshaded		Double-glazed Windows, Unshaded	
	Common Glass	Heat-absorbing Glass	Common Glass	Heat-absorbing Glass on Outside
North	31	17	24	17
South	48	24	38	24
West	89	47	73	47



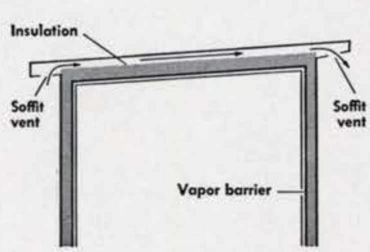
In gable roofs, screened louvers should be at high point of gable ends. Roof ventilator, chimney vents and soffit ventilators increase the effectiveness of wind currents.



Ventilated air in a gabled-roof, 1½-story house should be distributed through all areas behind and above second-floor rooms.



Soffit ventilators are necessary in hip roofs. Here ridge of roof is extended to form a small gable for louvers. Roof ventilator can be used.



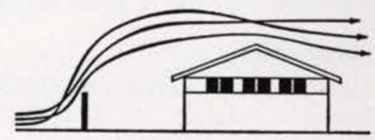
Cool air entering lower roof vent of shed roof forces hot air out through upper vent. In flat roofs, air currents cannot be relied on to force hot air out; a mechanical ventilator is recommended.

VENTILATION OF ROOMS

Houses should have some method of natural ventilation, either operating **windows** or ventilation openings such as **louvers.** The Federal Housing Administration requires a minimum ventilation area of 4 per cent of the room floor area, but more is desirable.

Windows or louvers should be placed and designed to take advantage of prevailing breezes. Location of landscape plantings, fences and tall shrubbery must be studied to be sure that they do not divert the prevailing breezes.

Because air continues to flow within the room in the same direction as it enters, the placement of the ventilation openings is extremely important. Air currents are slowed if they are forced to go around obstructions. The most effective air movement is obtained when ventilation openings are on opposite walls and the air flows across the room at the "breathing" level or within the height of human occupancy.

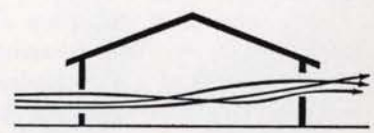


Avoid obstruction to air flow.

Exhaust Fans: Exhaust fans help to relieve heat and moisture conditions in the bathroom and the kitchen.

Night Air-Cooling with Fans

A house which is ventilated only by means of open windows, louvers, and doors on a calm summer night will not cool rapidly due to lack of air circulation. By operating fans — attic fans or window fans — throughout the night, large quantities of the cooler night air can be circulated through the house, and the indoor air temperature can be decreased more rapidly. If the windows and louvers are closed early in the morning, with only enough openings for ordinary ventilation, the house can then "coast" into a hot day at much lower temperatures than if the house were still overheated from the previous day. (If there is a cool breeze, the windows, of course, can be kept open during the day.)



Obtain effective air movement by placing ventilation openings on opposite walls.

Night air-cooling can reduce the indoor temperature to one or two degrees above the outdoor night temperature. Sudden breaks in outdoor temperature, which may cool a house below a desired level, can be taken care of by a thermostatic control which turns the fan off.

Night air-cooling has some disadvantages. There is apt to be noise from fans if located in living quarters. Dust is likely to be brought into the house. If night-time humidities are high, the humid air will be brought into the house.

Selection of Attic Fan: The size of the attic fan required for night air-cooling depends on 1) the floor area of the house, and 2) 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.

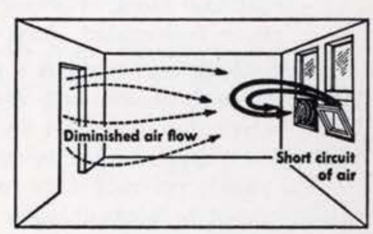
Approximate capacities of attic fans needed for houses of varying floor areas are listed below as a guide for selecting fans. Manufacturers' catalogues usually give full instructions for installation.

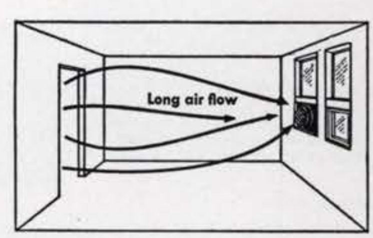
FAN CAPACITIES RECOMMENDED*

Floor area	Amount of air fan should deliver		
of house	For regions of cool nights		For regions of warm nights
800 sq ft	3000 cu ft/min	to	6500 cu ft/min
1000	4000	to	8000
1200	5000	to	9500
1400	5500	to	11000
1600	6500	to	13000
1800	7000	to	14500

Window Fans: While a window fan is easier to install than an attic fan, the former is limited in the area it can cool; also, it is likely to be noisy.

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

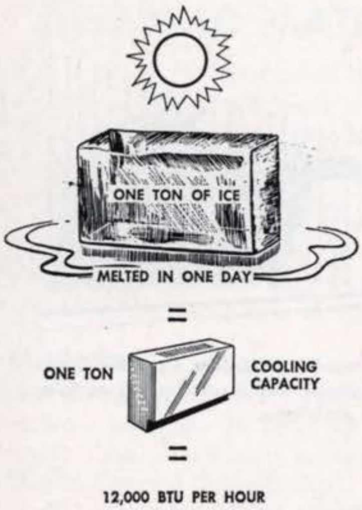




"Short circuiting" of air in window-fan installations can be prevented by closing adjoining windows and opening door to room.

* Capacities are for so-called "free air delivery." If obstructions or resistances to flow of air exist (such as louvers, screens, ducts), then the actual deliveries will be less than the "free air delivery."
In general, large, low-speed fans provide quieter operation than small, high-speed units.

CENTRAL AIR-CONDITIONING SYSTEMS



The capacity of air-conditioners, which was formerly expressed in tons, is now measured in Btu per hour.

Where the desired comfort cannot be obtained solely by house design and ventilation, the use of an air-conditioning system is suggested. Insulation, roof ventilation, and shading of the glass and wall areas are, of course, necessary for an efficient and economical operation. Sometimes with night-air cooling, it is possible to reduce considerably the number of hours that the air-conditioning system operates during the day.

While it is desirable to install central air-conditioning at the time of construction, this is not always possible. Space, however, should be provided when the house is planned so that future installation can be made without undue inconvenience. An air-conditioner for a house with a floor area of 800 to 1400 square feet requires 5 to 7 square feet excluding access space; for a house 1400 to 1900 square feet, 7 to 9 square feet. There should be access to the equipment from one or two sides.

Central air-conditioning equipment is available in many different sizes and shapes to suit the location — basement, first-floor utility rooms, and attic. Sizes of conditioners are generally given in terms of Btu per hour. Common sizes for residential use range from 18,000 to 50,000 Btuh and utilize motors from 1½ to 5 horsepower. Both gas and electric models are available.

The cooling equipment can be a separate unit called a **summer air-conditioner,** or it can be combined with the heating equipment in a single unit, a **year-round air-conditioner.** Air-conditioning equipment is manufactured for use with both warm-air and hot-water heat circulation systems. The general principles of operation are the same for both.

Another type of year-round air-conditioning system is the electrically-powered heat pump. The heat pump provides cooling in the summer by discharging the heat in the house to the outside air. In the winter, it extracts heat from the outside air, even when this air is at a low temperature, and uses this heat to warm the house. The heat pump is usually supplemented with electrical resistance-type heating in cold climates.

The operating costs during the summer are comparable to other types of mechanical cooling systems. Whether the heat pump is an economical installation depends on the comparative costs of heating between the heat pump and a fuel-fired furnace.

Room Air-Conditioners

Window and cabinet-type air-conditioning units can be used to cool small sections of a house.

The window units fit into an opening of a standard double-hung window and vary in size from ¾ to several tons of cooling capacity. Room air is circulated through the unit where it is cooled, dehumidified and filtered. No water pipes are necessary since the condenser is air-cooled; nor is a drain necessary inasmuch as the moisture condensed from the air is evaporated into the outdoor air. Electrically-operated, the units can generally be plugged into existing electrical outlets although a 230-volt service is required for most units having one-horsepower motors.

Evaporative Coolers

Evaporative coolers are effective in those areas dotted on the map.

Evaporative coolers are designed to take advantage of nature's system of cooling air by evaporation. When evaporation takes place, the temperature of the air is reduced.

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. The air is then circulated through the house.

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