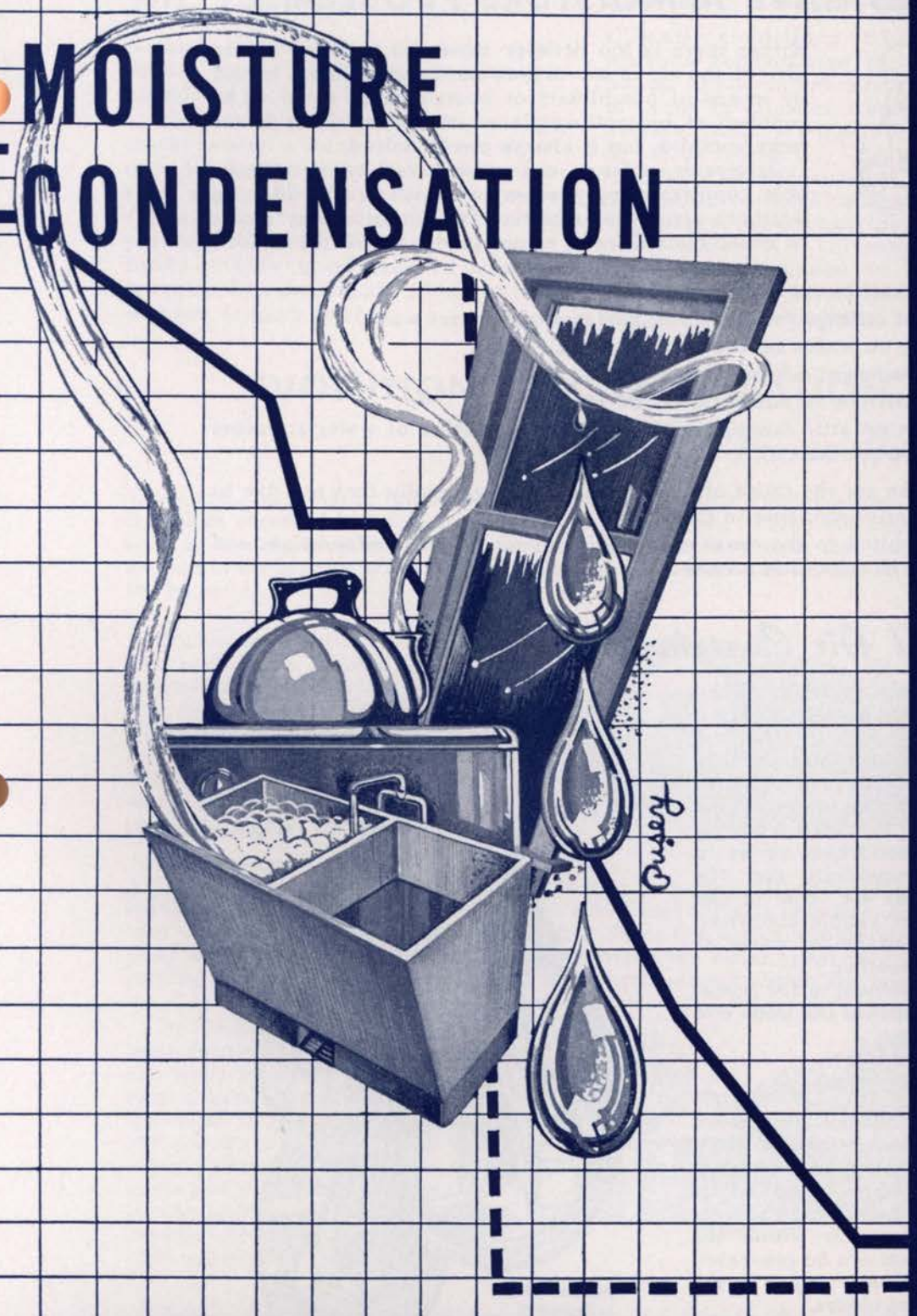
CIRCULAR SERIES

INDEX NUMBER F6.2

MOISTURE CONDENSATION



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MOISTURE CONDENSATION
SMALL HOMES COUNCIL F6.2

MANY HOMES HAVE A MOISTURE PROBLEM . . .

Either there is too little or too much moisture in the air. If the air is too dry, it can be made more humid by means of humidifiers or containers of water. The problem of controlling air which is too moist is far more complex, but it always can be solved.

Excessive moisture can cause a variety of undesirable conditions, only some of which are visible. In northern areas, this moisture condensation may result in water-spotted walls, ruined paint jobs, rotted lumber.

Evidence of condensation may present itself as:

- Damp spots on ceilings and room-side surfaces of exterior walls.
- Water and ice on inside surfaces of windows.
- Moisture on basement side-walls and floors.
- Water-filled blisters on outside paint surfaces.
- Marbles of ice on attic floors resulting from condensation of water at points of nails in roof boards.

In some cases, leaks are the cause of these troubles, but generally they are due to condensation of excessive moisture in the air.

This circular is limited to the ***cause of excessive moisture, its condensation, and effective methods for its control in homes in cold climates.***

All Air Contains Moisture . . .

This moisture (water vapor) is invisible. When the air is warm, it can hold more moisture than it can when it is cold.

When water vapor comes in contact with a cold surface, it condenses to form frost or water (depending on whether the temperature of the surface is below or above 32° F.). The temperature at which water vapor condenses varies in relation to the surface temperature and the amount of water vapor in the air. One of the most common illustrations of visible condensation in the home is the formation of water or frost on a window in cold weather.

Condensation becomes a problem to the homeowner when it occurs ***on or within the walls and ceilings.***

WATER VAPOR HAS PRESSURE . . .

The amount of pressure depends upon the amount of vapor in the air. This pressure forces moisture to areas which are drier (lower pressure areas). Excessive moisture within a warm house is thus forced to the outdoors in cold weather, and condensation ***on*** the inner surfaces ***or within*** the walls may occur. Condensation can be prevented ***by controlling the amount of water vapor*** in the house and its passage to the outdoors.

Since water vapor is invisible and is not easily detected until it condenses, the homeowner is usually unaware that water vapor is being supplied to the air. As a result, little thought is given to its control until condensation problems arise.

FACTORS AFFECTING CONDENSATION

1. Humidity of air within a building
2. Temperature and climatic conditions
3. Construction of exterior walls

SOURCES OF WATER VAPOR

Everyday household activities produce considerable moisture in the home. Humidifying devices and certain conditions resulting from the house structure itself may also produce water vapor.

Air Leakage

Natural air leakage is a major controlling factor which prevents excessive humidities within a home.

This leakage takes place through cracks around windows and doors, chimneys for fireplaces and furnaces, and, to some degree, directly through the walls (because most building materials are porous). Through these channels, the inside air with its accumulated moisture is replaced by outside air, which, in cold weather, is much drier.

CLIMATE AND CONDENSATION

Climatic conditions influence moisture condensation within a house. Condensation is most apt to occur in climates where the average January temperature is 35° F. or colder.

Effects of condensation may not become evident until sometime after condensation has taken place . . . i.e. moisture which has condensed to frost within the wall is not likely to be apparent until a thaw.

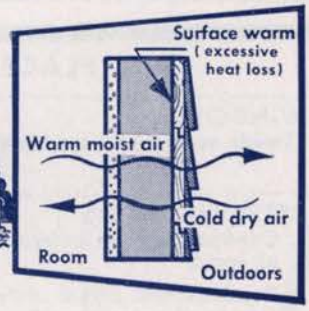
■ Average January temperature 35° F. or less

EVOLUTION OF CONDENSATION TROUBLES

. . . *In Frame Houses*

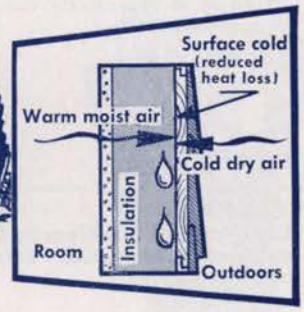
Years ago, the building industry was not concerned with condensation, for it seldom occurred in frame houses except on windows. These old houses were so loosely constructed that the exchange between outside and inside air due to air leakage was sufficient to control excessive humidities within the house.

Houses were built like this one. The ***walls were porous and uninsulated;*** the space within the walls was warm because of heat loss. There was no condensation except on windows, for the warm moist air from the house ***passed through*** the warm walls. ***The vapor did not condense within*** the structure.



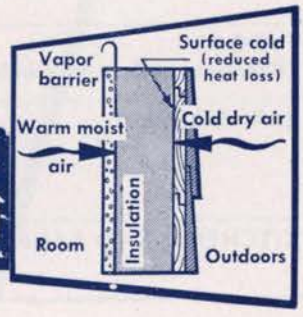
Condensation troubles began when the desire to save fuel brought into being tightly-constructed houses. These were built without effective moisture controls. The tighter walls (resulting from the use of weatherstripping, storm sash, caulking, insulation) prevented the warm moist air from leaking out of the house; thus, water vapor accumulated within the house.

In houses of this era, the ***walls were insulated.*** The space within the walls was cold for the insulation prevented heat loss through the walls. However, the ***walls were still porous*** to the passage of water vapor. Warm moist ***air from the room penetrated the inner surfaces of the walls and the vapor, if excessive, condensed*** when it reached cold surfaces within the walls.

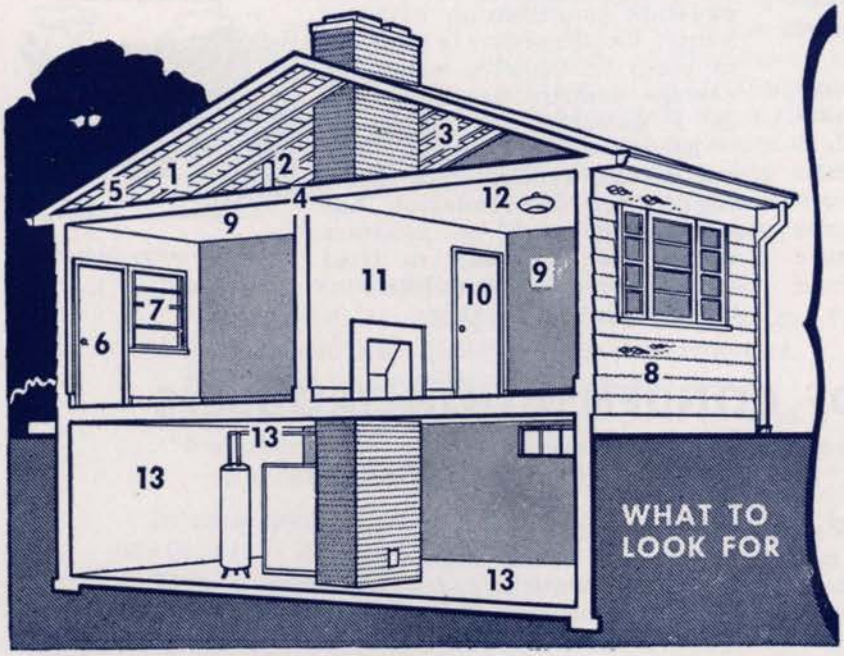


Today, the correct use of vapor barriers (membrane through which water vapor cannot readily pass) makes it possible to have tightly-constructed, insulated houses without wall condensation.

In insulated houses with barriers, the space within the walls is cold due to insulation, but the vapor barriers make the inner surfaces of the ***walls non-porous.*** The warm moist ***air from the room does not penetrate*** into the walls.



CONDENSATION IN THE HOME . .



ATTIC UNHEATED

1. Frost on underside of roof boards
2. Frost or water on soil pipes
3. Frost or water on nails in roof boards
4. Frost on underside of attic floors over an interior partition
5. Frost on cold surfaces over cornice

FIRST FLOOR

6. Frost on door handles and hinges
7. Water or ice on windows
8. Paint-peeling
9. Damp spots on walls and ceilings
10. Damp spot in closet
11. Condensation from flue products
12. Damp spots around light fixtures

BASEMENT

13. Water on cold water pipes, walls and floors in summer

PLACE	FACTORS
WINDOWS (Inside surfaces of windows)	Excessive condensation on the inner surfaces of windows may cause: (1) paint to peel from sash; (2) water to run down into window frame causing dampness around frame and perhaps paint-peeling on the outside of building.
EXTERIOR WALLS 1. Condensation *on* exterior walls and ceilings of room	Moisture may condense directly on cold surfaces of room. This occurs in certain uninsulated homes.
2. Condensation *within* ceilings and walls (inside of exterior wall)	Unobserved condensation may also occur within wall. Probability depends on humidity of inside air, outside temperature, and vapor permeabilities of wall.
CLOSET WALLS (Problem similar to that of exterior walls)	Condensation *on* or *within* such walls is caused by closet being unheated. The inner surface temperature of the wall becomes lower than the temperature at which moisture in inside air condenses.
ATTICS (Problem is essentially the same as condensation *within* walls.)	Condensation in attics may occur when: • Insulation is applied without vapor barriers in the upper ceiling or attic floor. (Roof boards become very cold as a result.) • Attic doors are poorly fitted. (Large volumes of high humidity air pass from living quarters to attic.) • Vapor penetrates the side-walls and passes to attic through them. • Vapor originating in basement passes through stud and furring spaces within walls which are not blocked off. • Vapor barriers, placed on underside of rafters, are not sealed at top and bottom, thus allowing air to circulate above barrier.
BASEMENT (Condensation problem in basement is a summertime problem, rather than a cold weather one.) *See Page 6 for notes on partially excavated basements or crawl spaces.*	Instead of being troubled with warm air passing to the cold outdoors, the basement is concerned with warm moist air from the outdoors on muggy days entering the cool damp basement. Condensation takes place when this warm air comes in contact with cool basement walls and floors and with cold-water pipes. Water leakage through walls (direct leak or slow penetration of moisture through wall) is another cause of moisture in the basement, but it is not a condensation problem.
FLOORS (Basement or first floor in basementless house)	Concrete floors laid on ground present condensation problem.
BATHROOM	Vapor from running bath water or shower condenses.
KITCHENS AND LAUNDRIES	Humidities are high because of cooking, washing and drying processes.

. . WHERE, WHY, AND WHAT TO DO

WHEN: Condensation is most apt to occur in homes at two specific times:

1. Within six months after a house is built. (Sources of excessive moisture are new plaster and fresh concrete.)
2. In excessively cold weather when interior humidity is high.

CONTROL OF HUMIDITY: In small, tightly-built homes, the moisture from normal living processes usually provides sufficient humidity for average comfort. Some people, preferring higher humidities, add humidifiers to heating plants. ***You can have whatever humidity suits you best if your home is built to prevent condensation.*** Uncontrolled humidity is apt to cause trouble with any type of construction.

CURES

The control of excessive humidities varies with the type of structure and the parts of a house. There are three principal cures which, singly or in combination, may correct condensation troubles:

Cure 1: Reduce interior humidity by:
Controlling water vapor at source
Ventilating
Eliminating deliberately added moisture

Cure 2: Use vapor barriers to stop flow of moisture through building materials.
Membranes (Metal foils and certain building papers)
Paints

Cure 3: Raise inner surface temperatures by insulating. (This eliminates visible condensation.)

CURES (In addition to reducing humidity)	NOTES
• Install: Double windows or Storm sash	Double windows permit about 33% relative humidity at 70° without condensation, compared with 14% with single window.
• Insulate walls	See Page 6 "By Insulating"
• Use vapor barriers	See Page 7 "By Using Vapor Barriers"
• For condensation on walls: Insulate, if house is uninsulated • For condensation within walls: Use vapor barriers	
• Ventilate attic • Prevent moisture from reaching attic by: ***Weatherstripping attic door*** ***Using vapor barriers*** to prevent moisture from penetrating side-walls, and ceilings under attics, as well as to seal off basement air from stud space.	Water found in attics is more often caused by condensation than by leaky roofs. See Page 8 "By Ventilating"
• Warm basement walls by: ***Ventilating*** (Open basement windows in dry weather.) ***Insulating*** (Be sure moisture does not get behind insulation.) ***Heating*** (Some water heaters warm basement air enough to reduce condensation.) • Use calcium chloride or other moisture absorbing material. • Insulate pipes with "anti-sweat" covering.	Often heavy foliage and shade will cause basement air to be damp, reducing effectiveness of ventilation. There must be adequate window area to make ventilation an effective cure. If moisture leaks in from outside, a vapor barrier at inside surface of wall is apt to trap moisture in basement wall and prevent its evaporation.
• Insulate by using gravel, cinders, crushed stone or other insulating material underneath floor. Good drainage is essential.	Install insulation at edges of slab.
• Install mixing faucets for hot and cold water. • Avoid running excessively hot water. • Install ventilator to bring in outside air. (Cold drafts from ventilators can be avoided by careful installation.) • Decorate bathroom walls with vapor resisting material (oil paint, linoleum, tile, etc.).	
• Ventilate (exhaust fan) • Decorate kitchen walls with vapor resisting material (oil paint, linoleum, tile, etc.). • Avoid excessive evaporation of water.	

BUILD HOMES TO AVOID CONDENSATION

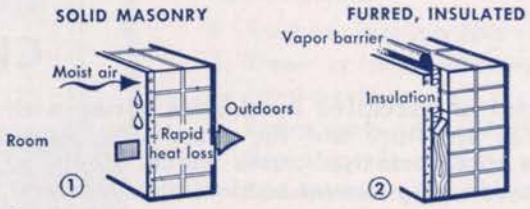
When a house is built, the degree of humidity which will ultimately be desired by the owner is unpredictable. The safest procedure, therefore, is to build the house to avoid any condensation difficulties which might result from excessive humidities. When plans for a house are drawn, provide ***insulation, vapor barriers,*** and ***ventilation.***

BY INSULATING

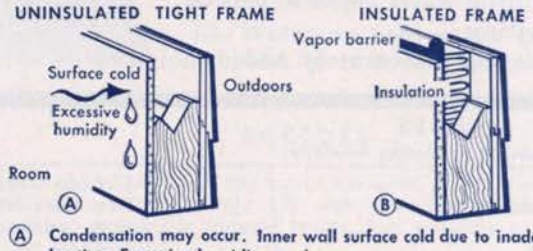
Visible condensation may sometimes occur on the room-side surface of an uninsulated exterior wall or ceiling. This condition is found in uninsulated masonry or frame houses of tight construction having excessive inside humidities, or in inadequately heated rooms or closets.

Insulation applied to these exposed walls not only conserves heat, but keeps the inner surface temperature of the wall warm enough to prevent condensation. *(See Small Homes Council Circular F6.0 — "Insulation in the Home.")*

Should vapor get into the outer sections of the walls, insulation may increase the likelihood of condensation ***in*** the wall since these sections are made colder by insulation. *(See sketches on Page 3.)* The solution is not to omit the insulation, but to use a vapor barrier to prevent vapor from penetrating the inner sections of the outer walls. Another solution, which may or may not prove an adequate cure, is to reduce the interior humidity, especially in cold weather, by controlling water vapor at its source.



① No insulation. Inner wall surface cold. Condensation may occur.
② Insulation raises temperature of inner surface. No condensation. (Only certain types of insulation suitable for this use.)



Ⓐ Condensation may occur. Inner wall surface cold due to inadequate heating. Excessive humidity condenses.

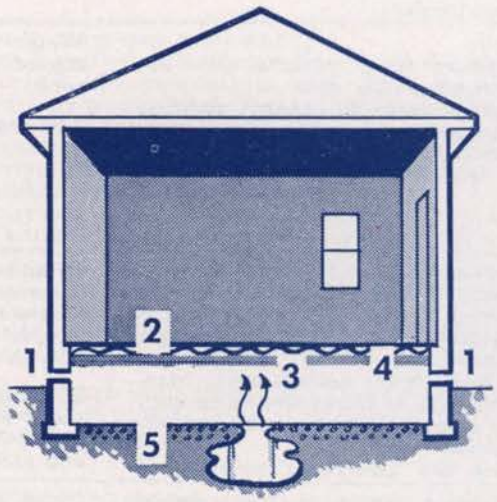
Ⓑ Inner surface warm. No condensation.

The Problem of Basementless Houses

To avoid condensation in a basementless house built over a 2- to 4-foot excavation (crawl space), the crawl space must be dry. *(See Small Homes Council Circular F4.4, "Crawl-Space Houses.")* Moisture can condense in the crawl space or it can rise through the floors and open stud spaces to other parts of the house, including the attic.

To prevent dampness within a crawl space:

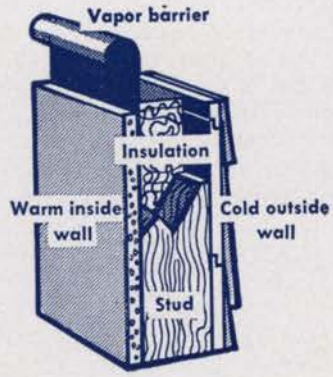
- Grade the lot correctly for good drainage.
- Use wide overhangs and/or gutters and downspouts to eliminate rain seepage.
- Lay moistureproof cover (*i.e.,* polyethylene film 4 or 6 mils thick) on the ground of the crawl space to stop capillary rise of moisture.
- Provide foundation vents to allow escape of moisture from the crawl space. If ground cover is used, only a minimum amount of ventilation is needed — four 8″ x 16″ vents for a house up to 1,400 square feet (provide an additional vent for each additional 350 square feet).
- Where floor insulation is used, install a vapor barrier either directly above it or between the subfloor and the finish flooring. The vapor barrier will prevent excessive moisture from the house traveling downward into the cold crawl space.



1. Screened vents
2. Vapor barrier
3. Insulation
4. Rot-proof joists
5. Ground cover

For concrete-slab construction, see *"Floors"* in chart, on pages 4 and 5 of this circular.

BY USING VAPOR BARRIERS



Use of a vapor barrier is the most effective means of preventing interior moisture from getting inside walls and ceilings. The barrier may be applied to the warm side of exterior walls or ceilings; it may be an integral part of the plaster-base or wallboard; or, it may be a membrane immediately back of the plaster-base or wallboard.

Vapor barriers should be used wherever the average January temperature is 35° or colder (north of the Ohio River). If exceptionally high indoor humidities prevail, however, vapor barriers should be used wherever any cold weather is experienced.

MEMBRANES: The several types of vapor resistant membranes are:

1. "Duplex" papers (or laminated) consisting of a continuous sheet of asphalt between two sheets of paper.
2. Surface-coated and glazed asphalt-saturated building paper.
3. Aluminum or other metal foil (usually paper-backed).

Ordinary asphalt-saturated roofing felt (paper) and building papers are not good vapor barriers as they permit passage of too much vapor.

To be effective, a membrane must be continuous and unbroken to prevent passage of moist air around the barrier. All joints must be lapped and securely fastened on studs, joists, or bracing.

In applying vapor barriers, don't overlook:

1. The space under the attic stairs.
2. Openings around ceiling light fixtures.
3. Openings in either exterior or interior walls which connect the attic space with the basement.
4. Cracks around attic doors.
5. Openings from stud space of interior partitions to the attic.

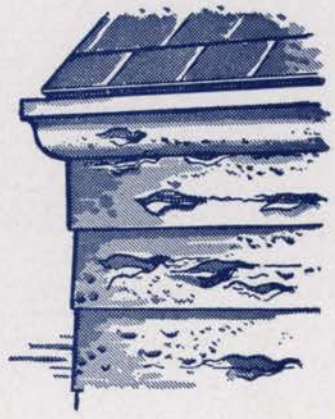
BARRIERS ON INTERIOR-FINISH BOARDS: Some plaster-base and wallboard with metallic foil or other barrier backing make satisfactory vapor seals for frame walls. Higher vapor permeability may be expected, however, for such barriers (depending upon the number of joints) than for continuous, unbroken membrane. Where wallboards are used as interior finish without plaster, the joints must be given special sealing.

PAINTS AND SURFACE FINISHES: Vapor-resistant paints and surface coatings also prevent water vapor from entering the walls.

Paints which are effective vapor barriers include most aluminum, asphalt, and lead and oil paints, and varnishes. Water emulsion paints as a group are not good barriers. Usually two or three coats of paint are required for satisfactory results.

BARRIERS FOR NEW CONSTRUCTION . . . AND OLD: ***Membrane or attached vapor barriers*** of known value are generally preferred to liquid vapor seals ***for new construction*** because coatings of paint may not be continuous and efficient. ***Paint or vaporproof wall coverings*** are preferred ***for existing structures,*** as they are applied more easily and at less cost.

Paint-Peeling



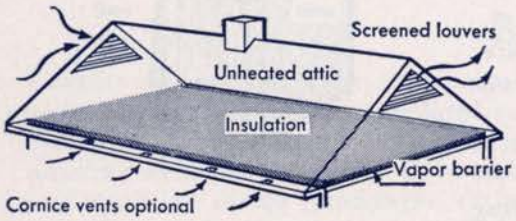
The tendency to blame insulation for paint troubles caused by condensation is not fair. Neither the insulation nor the paint is at fault. Rather, the blame lies on the lack of control of water vapor. (Poor paint, faulty application of paint, and exterior moisture also cause paint troubles, but they are not within the scope of this circular.)

Paint-peeling and paint-blistering may result from condensation of moisture within the house. Such moisture penetrates the walls until it reaches the underside of the exterior paint. The building materials through which the water vapor has passed are porous; the paint is not. As a result, the moisture gathers underneath the paint, forms blisters, and eventually the paint peels away from the wood. A membrane vapor barrier eliminates such difficulties by keeping moisture out of the walls.

BY VENTILATING

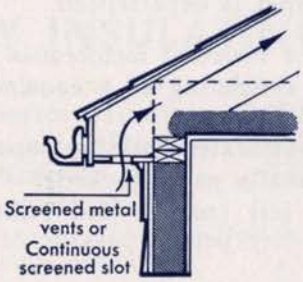
Excessive humidities in the house which cannot be controlled at their source can usually be reduced most effectively by ventilation. There is no fixed rule for the correct amount of air to be used.

It is more satisfactory to have a controlled source of ventilation than to depend on the uncontrolled ventilation from cracks around doors and windows. Air brought into the house by ventilation should preferably be heated (except in unheated attics) and the amount controlled and properly distributed. If the home is heated by a warm air furnace, an outside air intake can be added to the heating plant. *(See chart, Pages 4 and 5, for other recommendations.)* Ventilation should not be overlooked in the solution of any condensation problem.

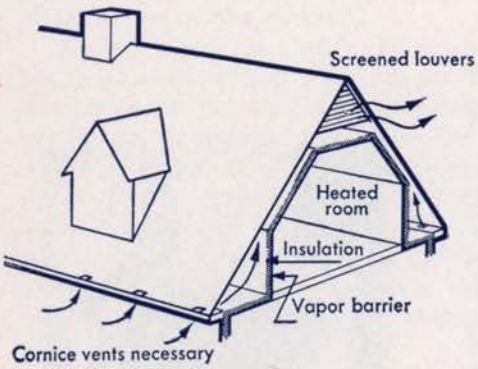


LOUVERS ON GABLE ROOF

Screened louvers should be at high point of roof.

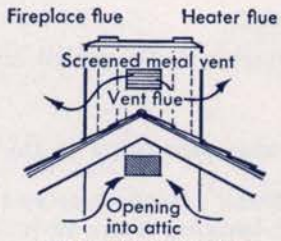


TYPICAL CORNICE OR EAVES VENT



VENTILATION OF 1½-STORY HOUSE

Ventilated air must be distributed over full area of attic including all areas behind and above second floor rooms.



VENTS IN CHIMNEY

Chimney vents adaptable to gable or hip roofs when inside chimney is centered on ridge.

Attics

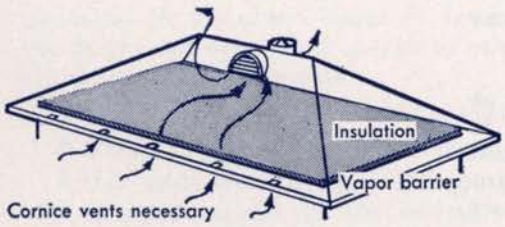
It is sometimes possible to prevent condensation in the attic by ventilating. Ventilation is not effective, however, in preventing condensation on the underside of attic floor boards. It cannot be used (except under the eaves and at roof peaks) if a warm attic is desired.

If insulation is placed on the upper floor ceiling and ***efficient*** vapor barriers are properly installed, attic ventilation is not necessary except to remove summer heat. Ventilating minimizes the condensation problem, but the best solution is to prevent the vapor from reaching the attic.

When an attic is to be ventilated, the air change requirements are:

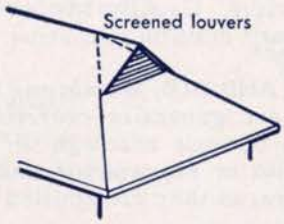
For vents: Total area of openings should be ***at least*** ¼ square inch per square foot of attic floor area. (Vents should be well distributed.)

For mechanical ventilation: 1 to 1¼ air changes per hour; or ***at least*** 6 cubic feet per hour per square foot of attic floor area.



ROOF VENTILATORS IN HIP ROOF

Two types of vents shown. Roof ventilators should be at high point of roof.



LOUVERS IN HIP ROOF

Ridge of hip roof extended to form small gable for louvers.

Flat Roofs, Shed Roofs

Houses with flat or shed roofs must have an efficient vapor barrier under the roof insulation. It is practically impossible to prevent accumulation of moisture by ventilation.

Ventilation, however, is necessary in such roof construction in order to prevent accumulation of hot air below the roof in summer and consequent buckling of the built-up roof.

The illustrations show suggested construction for both types of roofs. Vapor barriers are used to control moisture; vents, to remove hot air.