GABLE END VENTILATION
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GABLE-END VENTILATION

A report on the feasibility of providing gable-end ventilation units that will adequately eliminate rain and snow penetration.

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ABSTRACT

To improve summer comfort and eliminate attic condensation in the winter, louver units of increasing sizes are being installed in the gable ends of a large proportion of new houses. This practice has resulted in a new problem of rain and snow infiltration which frequently causes damage to the finished ceilings below.

This report:

I. Reviews the reason for attic ventilation of varying amounts and in various locations.

II. Explains the theory of air flow through ventilation units and the behavior of wind-driven rain and snow.

III. Identifies the various types and locations for ventilation units that will minimize rain and snow infiltration problems without seriously limiting the amount of ventilation that can be used.

IV. Recommends methods for improved attic ventilation by gravity air flow.
I. ATTIC VENTILATION REQUIREMENTS

A. Published Ventilation Criteria.

1. Winter Condensation Control

More and more top-floor ceilings of houses are insulated to prevent a loss of heat. This insulation reduces the temperature of the attic in the winter time. If enough water vapor enters the attic to bring the dew point to, or above, the surface temperature of the structural parts, the vapor may condense on rafters, roof boards and sometimes even on the ceiling joists. The condensation either penetrates the wood or, in event the wood is below 32° Fahrenheit, it freezes on the surface. If it freezes, it later on melts and often soaks into the wood. The danger of such absorption of vapor by wood members is that the moisture content of the wood may be raised to a point where decay hazards may arise. Unless ventilation keeps the moisture content of the wood below 20 per cent, there is a strong danger of attack by decay fungi.

Based primarily upon this need, a minimum net ventilation area equal to 1/300 of the attic area is usually required. (1)(2) The gross area with wood louvers and 1/8 inch mesh screens is 2 1/2 times the net area. (5) In case of a 1,000 square-foot house with a vapor barrier and one vent in each gable end, the required gross area of each vent would be 3.75 square feet. Twice this amount is recommended if no vapor barrier is used. The net area of the gable vent, however, can be cut to 1/900 of the attic area if soffit vents equal to 1/900 of the attic area are also used. Gable vents can be eliminated entirely if adequate roof vents are used high in the attic along with soffit vents.

Low vents, in the soffit or low in the gable, are not effective by themselves. In event the roof has a pitch of 2 inches in 12 or less, all vents are low. Such vents must have an effective area equal to 1/150 of the attic area.

2. Summer Comfort.

The sun beating on the roof of a house having a poorly ventilated attic can build up the temperature in the attic to 130° Fahrenheit. (9) Summer comfort and economy in the operation of air-conditioning equipment require adequate ventilation to prevent this build-up of hot air in the attic.
Very little data exist on which to establish the amount of attic ventilation that is desirable for summer comfort. There is good reason to believe that the amount of ventilation specified for winter condensation control would be less than adequate.

A combination of ventilation units, with \( \frac{1}{3} \) to \( \frac{1}{2} \) of the vents high and the rest low in the attic, is essential to allow the hot air to flow out without the aid of wind pressure.

If attic fans are used, the recommended ventilation units should be three times as large as specified for winter condensation control—i.e., 1/100 of the attic area. (1)

B. Insect control

There is a conflict between the size screen mesh that is best for insect control and the size that offers minimum resistance to air flow through the vent.

Air moving at the low velocities normally occurring in attic vents—i.e., one or two miles per hour—is greatly restricted by fine mesh screen. Published criteria specify that the gross area of vent to satisfy calculated net area needs must be increased 100% with 1/16-inch mesh screen; 25% with 1/8-inch mesh screen. With 1/4-inch mesh screen, no increase in vent area is needed. The control of insects, on the other hand, is best achieved with fine mesh screen. 1/8-inch mesh is generally accepted as the best compromise between the needs for insect control and the needs for maximum air flow. This subject will be discussed under rain control.

C. Bird control

Louvers of normal design encourage nesting of birds. This is especially true in northern climates where birds are attracted by the warmth of the air flowing out through the louvers in the winter time.

Nesting of birds can be eliminated either by locating the screen near the surface of the opening or by narrowing the openings between the louver slats. The wren is the smallest bird with which home owners usually are concerned. Oval openings in bird houses are sized \( \frac{7}{8} \)-inch high and \( \frac{1}{2} \)-inch wide to admit house wrens and keep out sparrows.

A wren would require more than \( \frac{7}{8} \)-inch in height between sloping louvers. Neither sparrows or wrens could enter louver
openings on a 45° slope with the slats spaced 1-inch apart. It is possible that sloping slats could be spaced up to 1½-inches apart and still keep out sparrows and wrens.

D. Rain and Snow control.

Under storm conditions, wind-driven rain or snow will penetrate many types of louvers and cause damage to the structure. This introduces water into the vulnerable parts of the house and frequently results in damage to valuable furnishings, warping of floors, loosening of plaster, etc. The amount of water admitted and the frequency of its occurrence varies according to the climate, building exposure, size and type of louver, and its position in relation to roof slopes, overhangs, trees, etc.

II. THEORY OF AIR FLOW - ITS INFLUENCE ON RAIN AND SNOW FALL-OUT.

A. Wind Direction and Pressure.

The number, size and placement of ventilation openings are all important elements in planning attic ventilation units.

The effectiveness of gravity flow through attic vents depends on the difference in the height of the inlet and the outlet openings, as well as the difference in temperature of the air in the attic and the air outside. A temperature difference of 30°F is common in attics. This will result in a pressure head causing a flow of air out of the upper opening. Such air moves at extreme low velocities—approximately two miles per hour. The amount and size of vent required are determined by this low velocity air movement since it is the one that acts most of the time, removing hot air in the summer and moist air in the winter.

Such vents, however, cannot be too large or located in areas of maximum pressure if rain and snow infiltration troubles are to be avoided.

1. Wind Intensity.

Even though winds are usually at a low velocity all but a few hours of the month, winds of high velocities occur in most localities, along with rain, during some days of each year.

An understanding of rain and snow infiltration requires a knowledge of the behavior of such winds around a house. As stated in published reports on wind pressure and natural
ventilation of houses (2), (6), (7), although the wind may have an over-all direction of flow, high winds are broken up by much turbulence and many small swirls. While steady winds may last more than several minutes, the highest velocities are reached in gusts of almost momentary duration.

Winds of 50 miles per hour are common for relatively long intervals of 10 to 15 minutes in almost all localities throughout the United States. Winds of 100 to 150 miles per hour are hurricanes. Many houses may never experience such winds, or if they do, the winds will seldom last longer than 1 or 1½ minutes.

In order to evaluate the ability of windows and louvers to withstand rain infiltration and strong winds, a test procedure was devised at the University of Miami. Two separate tests were devised using a high velocity artificial wind which was created by a 1200 horsepower airplane motor and propeller.

One test subjected the louver to gusts of wind with velocities changing from 80 to 140 miles per hour for a period of 1½ minutes. This test showed whether the louver was strong enough to withstand the pumping action caused by sudden changes in high velocity winds.

The other test subjected the louver to a wind of 100 miles per hour for 5 minutes with water introduced into the airstream at 20 gallons per minute. This test showed whether the louver would adequately limit the penetration of wind-driven rain.

These two tests illustrate the extreme conditions of wind and rain penetration which some louvers must withstand. Design for such extreme winds may not be essential in all parts of the country; however, all attic ventilating units should be designed to withstand rain borne by winds of at least 50 miles per hour.


Following are the principles of air movement for high velocity winds—about 50 miles per hour—as they affect vents in the attic:

a. A high-pressure area is created on the windward side when air strikes a building. This results in a air flow up and around the building. As a result, most winds strike the building at an upward angle, especially in the higher portions of the gable end where
the ventilating units are normally located. (See Figure 1A.)

b. Low-pressure areas are created on the leeward side of the building, resulting in suction which causes vents on this side to become air outlets even if they are located low in the attic.

c. Air flows into vents with maximum velocity if the vents are on the windward side—in the area of maximum pressure—and are sloped at the same angle as the wind flow. Wood louvers in gable ends are frequently located to satisfy all of these conditions of maximum penetration by high velocity winds. (See Figure 1B.)

d. Soffit vents adjacent to the house are in the area of greatest wind pressure. On the other hand, soffit vents located near the outer edge of the overhang are subject to far less wind pressure. (See Figure 2.)

e. Obstacles in the path of moving air cause it to change direction, thus slowing it down—i.e., slats on the back or front of louvers reduce the air speed. (See Figures 3C and D.)

B. Turbulence Controls Rain and Snow Penetration.

1. Rain and Snow Penetration of Conventional Louvers.

During a heavy wind and rain, an air cushion at least a foot or two deep builds up on the windward side of the house. This air cushion is nearly static, the oncoming air being deflected from it. The pressure in front of an attic louver is higher than the pressure inside and forces the air through at high velocity.

The oncoming rain, however, will carry through the air cushion due to its momentum, but it will travel in a straight line, sloping upwards due to the upward direction of the wind before it reached the air cushion. If a louver or a vent in the path of a wind has a continuous straight opening into the attic, the water will continue into the attic even though this path may have an upward slope. (See Figure 3.) A pinhole opening on the axis of the rain flow will admit more water than a loosely constructed baffle.

A detailed analysis of air flow through a conventional wood louver shows that the wind going through the louver is slowest immediately above each slat and increases to a maximum velocity a small distance away from the slat. A pattern of turbulence is created just below each slat, (See Figure 4A.) unless the wind is upswept at the same angle as the slats. (See Figure 5B.)

The thickness of the film of slow moving air above each slat depends upon the shape of the slat and the opening. Baffles on the back of the slats, for instance, will create a thicker film of slow moving air than when no baffles are used. If the film is thick enough, any water falling on the slat can run down into the path of the wind below the slat. If the wind is slow enough, none of this water will go through the louver. Baffles below and on the front of the slats will create more turbulence below each slat.

Rain entering a louver acts in three ways: (See Figure 5A.)

(1) Large wind-borne drops.

These drops fall steadily but with lateral velocity that varies with the wind velocity. When the drops pass into a louver, the wind may lift them. Due to their weight, however, they never rise above a specific "top line of rain climb" which is determined by the wind velocity, the angle of the wind, and the design of the louver.

(2) Large free-falling drops.

These drops fall from the front edge of louver slats without any initial lateral velocity. This water is collected on one slat and drips down into the path of the wind, entering the slot below. If the wind is sufficient, the drops will be blown into, but not necessarily through the louver. If not, they will be free-falling drops. Their "top line of rain climb" is always less than for the wind-borne large drops.
(3) Fine wind-borne spray.

This fine spray remains suspended in the moving air and settles very slowly. All snow acts in this manner.

Line of separation "A-A" divides the fine drops (which will contact the slat) from those above (which will blow through without contacting the slat).

A baffle at the back of a louver slat reduces rain and snow penetration in three ways: (See Figure 5B.)

(1) It blocks the path of large drops, both wind-borne and those dripping from the slat above.

(2) It thickens the layer of low velocity wind on top of the slat, thus allowing water to run down off the slat.

It also blocks the flow of water which may collect on the top of the slat and tend to blow upward into the attic.

(3) It raises the position of line "A-A" for fine spray, thus reducing the penetration of fine rain or snow through a louver.

A stop at the front and bottom of the louver slat blocks the path of fine spray or snow if it projects down to line "A-A". (See Figure 5C.)

At the same time, a front stop increases the slope of the "top line of rain climb", thereby making it even more difficult for heavy drops to penetrate; however, the front lip is less important than the back lip.*

b. Wind force required for rain penetration.

The ability of a louver to keep out heavy rain drops that drip from the slat above is proportional to the

*Without design data for the line of separation "A-A", it has generally been assumed that the downward projection of the baffle in front should be level with the upper part of the baffle on the back.
minimum force required to blow a free-falling raindrop through the slot in the louver. This force varies with changes in the slope of the "top line of rain climb" and the slope of the louver slat.

This force can be determined graphically as a function of the force of gravity. (See Figure 6.) The wind force "AD" will carry a raindrop, which starts without lateral momentum, along the minimum line of rain climb for penetration. Following is an explanation of the force diagram which relates "AD" to the force of gravity:

AB  Vertical line of specific length which represents the force of gravity acting on a raindrop.

AM  Line in direction of path of least energy required to carry raindrop into the house—i.e., parallel to line of rain climb for penetration.

BN  Line parallel to direction of wind force, which is assumed to be parallel to the louver slats.

AC  Line graphically equal to net force required to carry raindrop on minimum line of rain climb for penetration, as related to force of gravity. This net force results from the combined force of gravity and force of the wind.

AP  Line parallel to wind force.

CC  Line parallel to AB.

AD  Line equal to wind force required to carry raindrop inside of house as related to force of gravity—i.e., $2\frac{1}{4}$ times gravity in this example.

Based on this analysis, it is possible to establish a design criteria for the rain resistance of louvers. Below is the criteria which was used for the evaluation of various types of wood louvers.

The louver requiring the highest ratio of wind force to gravity force has the best resistance to penetration of heavy drops falling off the front edge of slats. Large raindrops carried directly by the wind can penetrate easier than those falling off the front edge of the slats. The ability of a louver to keep wind-borne drops from penetrating, however, can be assumed to be directly proportional to the ability to keep out free-
falling drops; hence, the louver requiring the greatest wind force to offset gravity will have the best resistance to rain penetration. Snow penetration has to be controlled by other means.

A graphic analysis of various types of louvers with various widths of slats and various slopes reveals that a louver made with 1" x 6" slats spaced 1-inch apart on a 45° slope will give the best possible resistance to rain penetration.

c. Influence of Screen on Rain and Snow Control.

Tests conducted at Miami University (6) show that outside screens on double-hung windows resulted in water piling up between the window and the lower member of screen frame. The water came into the large area of the screen much faster than it could drain out any holes in the bottom of the screen frame and caused a collection of water that was difficult to control. Test No. 178 also conducted by the University of Miami showed that more water was admitted through a louver backed up with 16-mesh screen that the louver with 1/8-inch mesh screen. Wind velocities are reduced 35 to 50 per cent by 16-mesh screen going through openings at a rate of 1 to 10 miles per hour. (3) Until further research work is done, 1/8-mesh screen is recommended as the best control from rain infiltration and insects.

In areas where snow infiltration through louvers is anticipated as a serious problem, it may be necessary to use 1/4-inch mesh screen. The 1/8-inch mesh screen collects the snow and builds up an ice coating which blocks the functioning of the ventilation unit. The frequency of this occurrence is not known and further research is necessary to identify the importance of this problem.

2. Patented Rain-Proof Louvers.

In an effort to locate economical patented rain-proof louvers, several manufacturers were contacted. One firm publishes literature advertising a storm-tight stationary louver. This is made of aluminum with a double baffle. None of the literature quotes tests proving the storm-tight quality and the recommended specifications do not contain reference to the storm-tight quality of the louver.
One of the louver manufacturers was interviewed to determine what success that firm had in creating economical rain-proof louvers. This firm pointed out that such a louver could be built if price was not a factor. The depth of the louver would probably have to be 6 inches instead of 1\(\frac{1}{2}\) or 2 inches as is customary with most metal louvers, and the price would be well in excess of the price that home builders probably would be willing to pay. This firm felt that it was far better to use its roof ventilator units which are more readily manufactured in a weatherproof design, and, as stated earlier, have been recognized in some codes as requiring less area than a gable vent.

3. Soffit and Rake Vents.

The eave soffit of an overhanging eave is well suited for part of the openings for attic ventilation, but eave soffit vents alone will not allow air to flow by gravity circulation. A similar vent located in the bottom of a projecting rake on gable ends can provide the needed outlets high in the attic.

If the vent in a soffit or rake is located immediately adjacent to the house, it will be in the area of maximum air pressure and will be subjected to noticeable rain and snow infiltration. (See Figure 2.) Placing the vent opening near the outer edge of the soffit or rake will minimize the pressure from wind and increase the turbulence and friction which will slow down air forced into the opening. At the same time, the surface which will be dampened by any wind-driven rain will be the soffit or rake boards, not the finished ceiling of the house. These soffit boards can be of a material that will withstand some wetting. These boards usually slope so that any water can be readily drained off.

III. RAIN AND SNOW PROOF VENTS.

A. Louvers.

1. FHA Requirements, Miami, Florida.

The Miami FHA-insuring office has benefited from the reports of the University of Miami Housing Research Laboratory in establishing criteria of acceptability. Gable ventilation units used in that area are fixed louvered type and are of metal, wood or concrete. According to the FHA recommendations, all units should have sufficient strength to withstand gusts of wind up to 140 miles per hour. Metal pans, which are
required inside the attic to reduce water infiltration, should be designed so that the pan does not reduce the open area when installed in the structure. Eave soffit vents shall be kept away from the exterior wall, and gable-end vents should be dropped as far as practicable below any gable over-hang.

These criteria seem valid in the light of available data. The supplemental design criteria given below are also recommended.

2. Design Criteria.


Conventional wood louvers may continue to be used; however, any designer should recognize their limitations.

To avoid problems of rain and snow infiltration, it is important to recognize all of the limitations specified under the above recommendations of the Miami FHA office. In addition, it is desirable to limit the size of such louvers. It would be foolish, for instance, to use wood louvers to satisfy all of the ventilation needs for an attic fan. It is important that gable louvers be supplemented with soffit vents so as to reduce the area of the louvers.

The use of 1" x 6" slats at a 45° angle with 1-inch space between slats is the optimum design from the point of view of cost and control of rain, snow and bird penetration.

Outside screens have frequently been used as a means of overcoming problems of rain and snow infiltration. This has definite aesthetic limitations and should be reserved only for use as a corrective measure.

b. Metal Louvers.

As stated earlier, the baffles at the front and the back of the slat, which are commonly used in metal louvers, are an aid in reducing snow and rain infiltration. On the other hand, metal louvers are generally shallower than wood louvers. Although there is no test data, a metal louver 1½ inches deep does not appear to prevent rain and snow infiltration any more than the best type of wood louver described above. Double baffles obviously are better, but further research data
are necessary before the term, "storm-tight", can be considered acceptable for this type of ventilating unit. All of the precautions mentioned above for wood louvers would also apply in the design and use of this type of metal louver.

The motor-controlled or manually-operated metal louver which can be closed in event of rain will, of course, provide adequate protection against such infiltration.

B. Rake Vents.

The installation of a ventilation unit in the soffit of a projecting rake on the gable will make it possible to build a virtually rainproof vent which will remove hot air by gravity from the high section of the attic. Such vents should be located near the outside face of the rake. (See Figures 7B, 8B and 9.) The opening can be provided in a number of different ways. Two obvious ways are: (1) by drilling holes in the soffit of the rake projection, and (2) by installing a continuous screen slot. The use of holes will limit the amount of ventilation to be provided. For instance, if holes 2 inch in diameter are to be drilled for a 1,000 square foot house, and if the amount of ventilation to be provided in the soffit of the rake projection is \( \frac{1}{900} \) of the attic area, a total of 100 square inches of vent will be required at each gable-end. The two-inch diameter holes with an area of 3.1 square inches mean that 32 holes will be required. If these are spaced six inches on center, the holes can be located within eight feet of the peak. If the vented area is to be increased, additional holes would either have to be placed closer together or would be located further down from the peak than is desirable.

The use of a 2-inch continuous slot, however, will provide the minimum ventilation, \( \frac{1}{900} \) of the attic area, with slots 25 inches from the ridge on both sides. The amount of vented area can be readily increased to 4 or 6 times this minimum by use of a wider and a longer slot.

There are many ways to apply the screen over these vents, but certain ways minimize the labor involved in its application. The use of the drilled holes with the screen stapled to the back side is one of the obvious and easy ways to achieve this.

The effective area of the vent can be increased if the screen is curved up, rather than nailed flat, against the back of the opening. By this technique it is possible to reduce the size of the vents to equal the net opening since the screen area becomes larger than the opening. (See Figure 9C.)
C. High Gable Projection.

Another new type of gable vent, which is growing in popularity, is created by projecting part of the roof out a foot or two and creating a triangular-shaped unit reminiscent of bird houses sometimes built on the gables of garages. An opening can be left in the bottom of this projection for the purpose of ventilating the attic. A similar type of vent is easily provided on houses which have projecting rakes on the gable end. (See Figures 7C, 8C and 10.)

With this type of vent, the air has to turn up vertically and then make a 90° turn before entering the attic. This last turn occurs in an area outside of the attic. The rain that is carried up vertically tends to continue up and is stopped by the projecting part of the roof; hence, the rain falls back out while the air turns and goes into the attic.

Any screen in the opening should be placed as close to the bottom as possible to avoid the problem of birds' building nests inside.

Houses with louvers under projecting rakes are often subject to excessive rain infiltration because the louver is so located as to receive the maximum wind pressure and rain drive. Such louvers can be protected by a similar type of triangular sheet placed even with the facia of the projecting gable and installing it so that the air has to flow up and turn before entering the louver. This forms a turbulence pattern which will eliminate any noticeable rain penetration.

D. Ridge Vent.

The use of a continuous vent along the entire ridge of the house provides an opportunity for a large vent which is particularly well-positioned to take care of the gravity flow of hot air in the summer. Such vents, of course, must be supplemented by an equal area of vents in the soffit. Ridge vents can be readily built with a high curb so as to minimize rain and snow infiltration. A decorative version of this same type of unit has frequently been used on garages, and there is no reason why it should not be used on the houses where it can serve a useful function as well as being decorative. (See Figures 7D and 8D.)

E. Roof vents.

Sheet metal roof vents, which were discussed earlier, are the best type of rainproof and snowproof ventilating units commercially manufactured today. The published engineering standards for vents allow smaller amount of effective vent area when units of this type are used.
The rotating mechanical type of ventilator, which is commonly used in industrial buildings, would be most effective but it has strong aesthetic limitations which prevents its use in residential construction. With imaginative design, there is no reason why such vents could not be made more attractive. (See Figures 7E and 8E.)

F. Dummy Flue in Chimney.

An efficient way to obtain a high stack-height for an attic vent is by use of a dummy flue in a masonry or prefabricated chimney. Such flues can be designed so that any rain or snow that accumulates is drained from the bottom of the flue. The chimney would have to be properly located to draw air out of the highest part of the attic. This limitation would rule out the use of chimney vents on houses with the chimney near the eave walls. (See Figures 7F and 8F.)

IV. CONCLUSIONS

Recommendations For Improved Attic Ventilation.

The aesthetic appeal of the wood louver has been a major factor in its continued and popular use; however, the limited ability of wood louvers to control rain and snow infiltration, especially when the units are sized to provide adequate ventilation for summer comfort, makes these units far less practical than other types. The substitution of a metal unit of similar design seems to offer little economic advantage, especially since it offers very small improvement in resistance to rain and snow penetration unless the most expensive type is used.

The best techniques to get large ventilation areas for attics are: (1) by use of concealed vents, such as those located in the soffit of the rake and eave projection, or those concealed in the chimney; and (2) by the use of a new type of decorative ventilation unit.

The ridge vent offers definite possibilities for the latter. If a large amount of ventilation is needed for summer or winter comfort and a good-looking unit can be designed, some extra expense for such a unit would be justified.

Custom-made ridge vents are too expensive for general use. The cost of this element of the house can best be reduced by the manufacture of a properly engineered ridge vent. Such a unit would remove moisture in the winter, reduce the cooling loads in the summer, and add an interesting design feature to the house.
REFERENCES

A partial list of references reviewed in this study and referred to in this report is given below:

(1) Minimum Property Requirements for Properties of One or Two Living Units - Located in the Southern Illinois District - Federal Housing Administration, including revision through October 1953.


FIG. 1

HIGH VELOCITY WIND MOVEMENT

A AROUND BUILDING

B THROUGH LOUVER
FIG. 2
WIND-DRIVEN RAIN PENETRATING
SOFIT AND RAKE VENTS

Vent next to house is in the area of greatest wind pressure, and frequently allows rain or snow to penetrate and excessively dampen the ceiling construction.

Vent at the outer edge of the overhang creates turbulence which reduces wind, snow and rain penetration.

Any water that penetrates falls on the soffit boards. These can be sloped so the water can drain off. They can also be finished with wood or other material which is less sensitive to water damage than ceiling materials.
The greater the turbulence, the less the chance there is that wind-borne rain will penetrate through an opening.

Horizontal winds have more turbulence than upsweped winds and, therefore, will not carry rain through louvers as easily as upsweped winds.

A so-called "stormproof" louver creates a turbulence pattern that keeps out rain when winds are horizontal but not when they are upsweped.

Rain tends to travel in a straight line even though the wind may be deflected. Protection from rain penetration with high velocity winds requires a vent without a straight path for rain travel, such as the type shown in Figures 8B, 8C, 8D, 8E and 8F.
The wind velocity is slow next to the slat, leaving a layer of slow moving air. If this layer is thick enough, it will permit water to run off of the slat.

The louver performs differently with a horizontal wind than with an upswept wind. The latter has greater air flow through the louver, but neither one can restrict the run-off of water that collects on top of a slat if the wind is high enough.

If louver is to be made of 1" boards, 1" x 6" slats spaced 1" apart on a 45° slope will give best resistance to rain penetration and keep out English sparrows.
FIG. 5
RAIN AND SNOW ENTERING A LOUVER

A-SIMPLE LOUVER

A - Large Wind-Borne Drops.

B - Large Free-Falling Drops.

C - Fine Wind-Borne Spray or Snow.

KEY

A - A Line of Separation.
FIG. 6
WIND FORCE REQUIRED FOR RAIN PENETRATION

MINIMUM LINE OF RAIN CLIMB FOR PENETRATION

WIND
GRAVITY

O
P
N
M

A
WIND

B
GRAVITY

C
D
FIG. 7
AIR FLOW THROUGH VARIOUS ATTIC VENTS
WHEN WIND IS BLOWING

A LOUVER HIGH IN GABLE - WIND ON GABLE END

B RAKE VENT - WIND ON GABLE END

C HIGH GABLE PROJECTION - WIND ON GABLE END

D RIDGE VENT - WIND ON EAVE SIDE

E ROOF VENTS - SHEET METAL - WIND ON EAVE SIDE

F DUMMY PLUG IN CHIMNEY - WIND ON EAVE SIDE
FIG. 8

GRAVITY CIRCULATION OF AIR THROUGH VARIOUS ATTIC VENTS WITH AIR INTAKE THROUGH EAVE SOFFIT

A. LOUVERS HIGH IN GABLE

B. RAKE VENT

C. HIGH GABLE PROJECTION

D. RIDGE VENT

E. ROOF VENTS - SHEET METAL

F. DUMMY FLUE IN CHIMNEY
FIG. 9
GABLE RAKE VENTS

A DRILLED HOLES

B CONTINUOUS SCREENED VENT

C CURVED SCREEN INCREASES THE EFFECTIVE AREA OF THE VENT
FIG. 10
VENT IN HIGH GABLE PROJECTION

A- GABLE WITHOUT PROJECTING EAVES

B- GABLE WITH PROJECTING EAVES