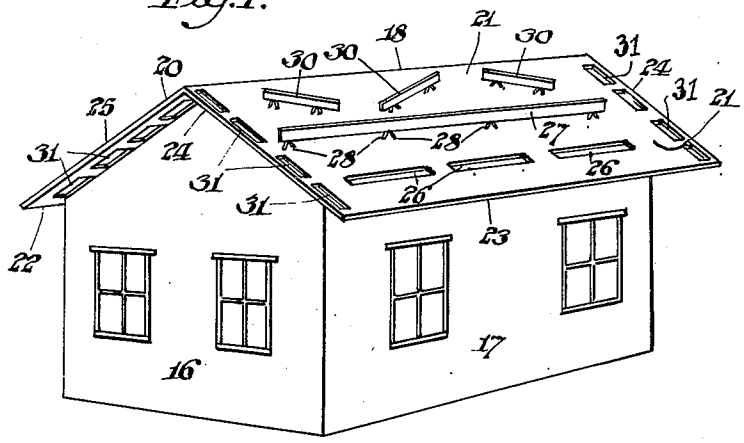
Jan. 20, 1942. C. T. LUDINGTON 2,270,538

BUILDING STRUCTURE

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Fig. 1.



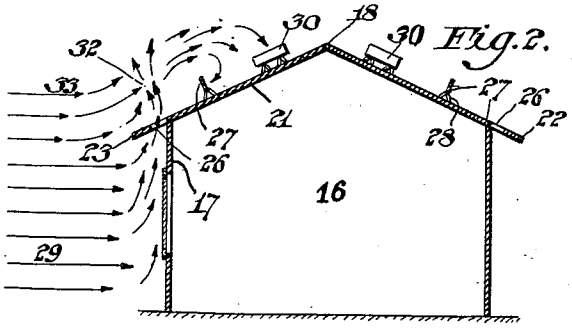


Fig. 2.

Fig. 3.

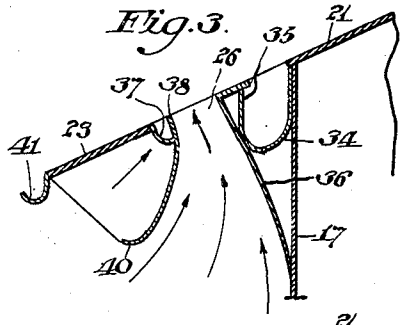


Fig. 4.

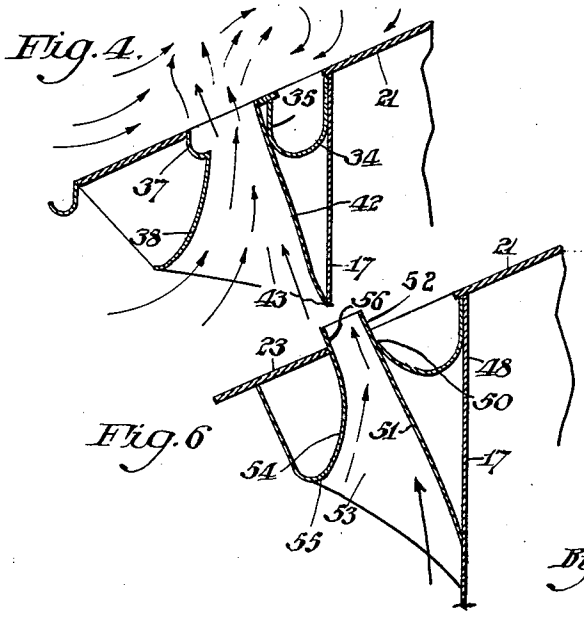


Fig. 5.

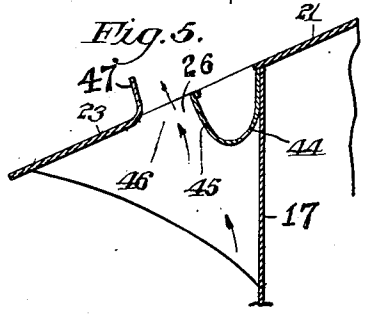


Fig. 6

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BUILDING STRUCTURE

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Fig. 7.

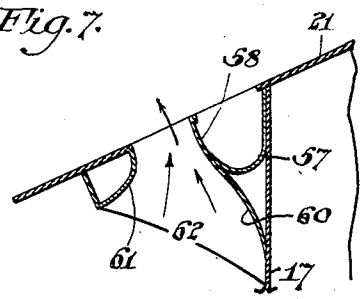


Fig. 8.

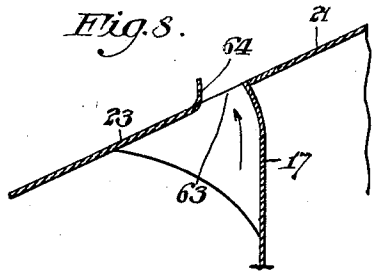


Fig. 9.

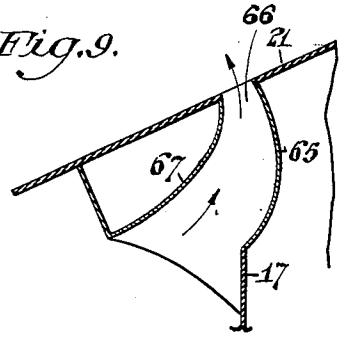


Fig. 10.

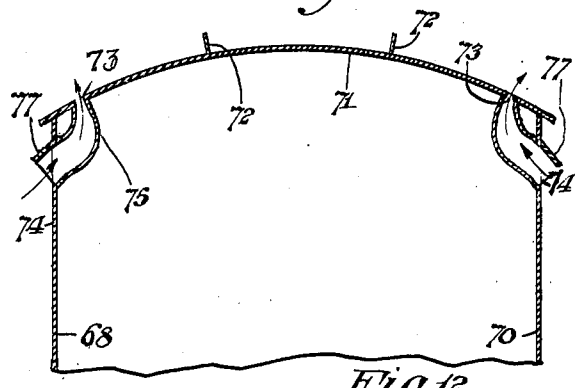


Fig. 11.

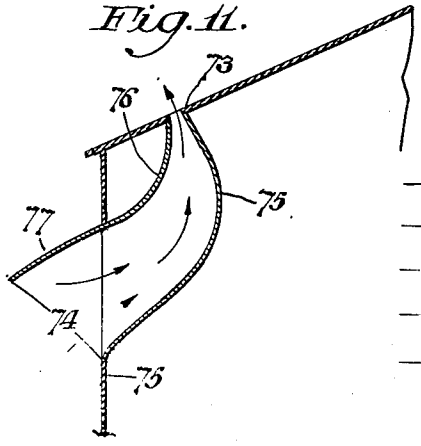
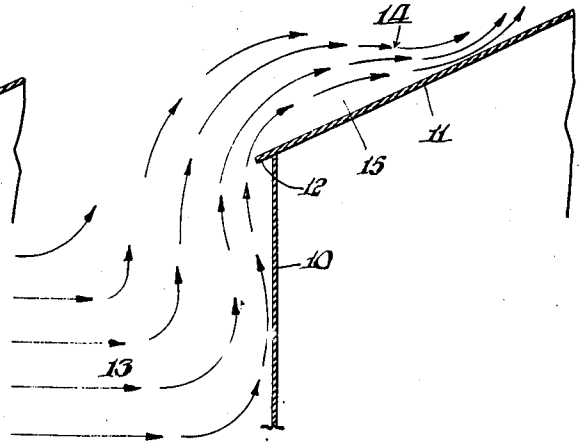


Fig. 12.



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Patented Jan. 20, 1942

2,270,538

UNITED STATES PATENT OFFICE

2,270,538

BUILDING STRUCTURE

Charles Townsend Ludington, Ardmore, Pa.

Application February 20, 1941, Serial No. 379,785

9 Claims. (Cl. 108—1)

This invention relates to building structures, pertaining particularly to building structures which are resistant to adverse effects attaching to exposure to relatively high winds such as cyclones, tornadoes and the like.

In an application #347,333, filed December 23, 1938, now matured into United States Letters Patent #2,206,040 there was disclosed an invention in roof constructions by which the smooth accelerated flow of air over roofs could be interfered with by the creation of predetermined turbulence in the air flowing over the roof with a resultant beneficial killing of the reduced pressure external of the roof and therefore a reduction in the differential pressures on the inner and outer sides of the roof, that otherwise might unroof the building supporting the roof, under high wind conditions.

Further research indicated that a contributing factor of great importance in the creation of differential pressures internally and externally of the roof lay in the flow of air up and along the vertical side walls of the building. In an application #255,190 filed February 8, 1939, there was disclosed means disposed on the vertical walls to interfere with the free flow of air upwardly thereof, by the creation of predetermined degrees of turbulence therein. The illustrative means comprised elements mounted upon said walls to minimize or reduce the velocity of vertical flow and thus the effective velocity of the compound or resultant flow over the roof occasioned by conversion and redirection of the horizontal flow against the side walls into vertical flow merging with flow directly over the roof. The inventions disclosed in the last mentioned applications are important and quite effective, but in some cases the side wall treatments have adversely affected the appearance of the building.

It is among the objects of this invention; to improve the inventions set forth in said applications 247,333 and 255,190; to provide a device of simplicity and economy for securing predetermined turbulence in air flowing over roofs while maintaining the appearance and normal functioning of the structure; to provide a synthetic roof spoiler securing desirable turbulence in air flowing over the roof to prevent the creation of unroofing differential pressures; to provide a building structure such as to convert stagnation pressure and low velocity resulting from impingement of air at high velocity against the side of the building, into high velocity low pressure jet energy projecting into the relative air stream at such angular relation thereto as to cause substantially predetermined turbulence therein; to provide building elements permitting the free flow of water and the like but which are designed to prevent the smooth flow of air across a roof; to provide hurricane-proofing for buildings at extremely small costs; to provide a building with a roof so arranged that it is resistant to unroofing differential pressure regardless of the direction from which the wind is coming as regards its relation to the side walls or roof; and many other objects and advantages will become apparent as the description proceeds.

In carrying out the invention in a preferred embodiment slot exit jets having substantially venturi characteristics are disposed in the roof in such manner that stagnation pressure of air against the side walls directs air into the slots where the low velocity high pressure energy is converted into high velocity low pressure energy in a stream so directed as to interfere with and preclude smooth accelerated flow over the roof by securing predetermined turbulence therein.

In the accompanying drawings forming part of this description,

Fig. 1 represents a perspective view of a purely illustrative building, in a disclosure illustrating the general relation of the slots and their auxiliary or supplemental components to the walls and roof of the building.

Fig. 2 represents a schematic diagram showing the silhouette of the building having a sloping roof, eaves, side walls, slots between the eaves and the roof and illustrative supplemental turbulence creating devices externally on the roof and schematic flow lines of high velocity wind impinging and crowding against one side wall and projecting through the slot in a jet emission angularly divergent from the roof to create substantially predetermined turbulence in the resultant air flow over the roof.

Fig. 3 represents a fragmentary schematic diagram of a detail of the roof slot and eave construction associating rain gutters with the venturi throat.

Fig. 4 represents a similar fragmentary schematic diagram of a modified form of throat.

Figs. 5, 6, 7, 8 and 9 represent further fragmentary modified forms of slot formations in diagrammatic disclosures.

Fig. 10 represents a fragmentary diagrammatic section of a modified form of wall, roof and slot assembly.

Fig. 11 represents an enlarged diagrammatic detailed section of the device of Fig. 9.

Fig. 12 represents a fragmentary schematic diagram of a portion of an unslotted building showing the resultant flow over the roof resulting from impingement of air against a side wall augmenting the energy of the accelerated flow over the roof which this invention obviates.

Referring to Fig. 12, it will be observed that the fragment shows a side wall 10 and roof 11 and a short eave 12. Air streams 13 moving against side wall 10 pile up against the side wall 10 to increase the static pressure in the area in a manner analogous to the retardation of air impinging against the frontal portions of streamlined shapes in aircraft. The entire area of wall 10 is subjected to this stagnation pressure and the air streams 13 being diverted upwardly and laterally merge over the eave with the air streams 14 flowing over roof 11 to furnish a low pressure area 15 which is dangerous to the roof as it is so much lower in pressure over the roof externally than the atmospheric pressure internally that the roof is frequently removed by such differential. The low pressure, of course, is a function of the acceleration of the joint air stream flowing over the upper roof 11. The first patent application referred to provided "spoilers" on the outer surface of the roof 11 to retard the flow by generating turbulence while the latter of the two mentioned applications referred to the provision of spoiler devices on the side walls, either alone or in combination with similar or analogous devices on the roof, to create turbulence in the upward flowing stream as well as that which seeks to flow across the roof. The consequent prevention of upward acceleration has assisted in the prevention of acceleration of the flow across the roof. The provision of laterally projecting devices upon the side walls has been very effective for the purpose, but obviously in many cases the appearance of the building has not been enhanced by such spoiler devices.

Referring to the fragmentary perspective of Fig. 1 a building is disclosed having an end wall 16 and a side wall 17. For illustrative purposes a roof having a ridge or peak 18 extending generally normal to the end wall 16 is formed of flat sloping surfaces 20 and 21. In the preferred embodiment each roof portion 20 and 21 respectively include lower projections in the form of eaves respectively 22 and 23 and each also project beyond the end wall 16 in side eaves respectively 24 and 25. It will be understood that the roof portions 20 and 21 are substantial duplicates and the latter only will be described in detail. Substantially in line with side wall 17 a plurality of slots 26 are provided between the eave 23 and main part of roof portion 21, for a purpose to be described. Preferably additional spoiler devices such as the elongated continuous plate or rail 27 mounted on supports 28 so as to be clear of the roof 21 to permit proper drainage beneath it may be used or a plurality of staggered spaced ribs or projections 30 may be disposed between the slots and the ridge 18. The spoilers 27 and 30 are so disposed and are of such area as to secure predetermined turbulence in the air flow over or past them to reduce its velocity and to preclude unroofing differential inner and outer pressures. In line with the wall 16 the roof portion 21 has a plurality of preferably aligned slots 31, the purpose and functioning of which will be explained and is similar to that of slots 26.

The schematic disclosure of Fig. 2 may be considered to represent a profile of the building of Fig. 1 with the wind coming against wall 17. The slots 26 are in substantial alignment with the wall 17 between the eaves 23 and the roof portion 21. The air stream represented by arrows 29 piles up against the outer eaves or wall 17 and is converted into pressure upon said wall. As the pressure spreads laterally and vertically of the wall it is caused to pass through slot or slots 26, which as is hereinafter pointed out is especially constructed to furnish a jet outlet, and is converted into a high velocity jet which is projected vertically in general parallelism with wall 17, but into the space above roof portion 21. In the preferred embodiment the jet emission comprises a stream of high velocity as at 32. The air stream represented by arrows 33 would normally accelerate a flow smoothly over roof portion 21 with adverse effects if the velocity was sufficiently high. Owing to the fact that some portions of the air stream 29 are now being projected transversely to the flow lines 33, there is generated a turbulent flow which is a retarded flow and prevents smooth high velocity flow and the acceleration of air flow over the roof which is the dangerous factor under high wind conditions. Depending somewhat upon the proportions of the roof, it may be necessary or desirable to provide supplemental or auxiliary devices to augment the turbulence, such as spoiler 27 or 30 or the like, or combinations of such spoilers may be used, to continue the minimization of the acceleration of airflow over the roof.

It will be observed that in an analogous manner airflow striking wall 16 (of Fig. 1) will cause the vertical passage of the high pressure air to conversion into high velocity jet emission through slots 31 to break up or to interfere with the airflow longitudinal of the ridge 18 and of the roof portions 20 and 21. In this connection the staggered elements 30 are equally effective to continue the "spoiling" as their angular relation is such as to oppose flow in any direction over the roof portions 20 and 21, while enabling free drainage thereabout.

It is to be observed as a necessary attribute of the invention that the projected jet of high velocity air should be at such angle relative to the roof flow approaching or even exceeding the normal by inclining into and against said flow as to create turbulence, and not be at such reduced angle away from the normal inclining into and with said flow and approaching parallelism with the roof as will enhance the flow and increase the acceleration of the air streams flowing over the roof. In other words it is important to remember that the angular relation of the air jet through or past the roof must be such as to function as a spoiler rather than as a flow accelerator such as might be derived from a leading edge slot of an airfoil.

In order to carry off rain water and therefore to secure all of the proper functions of the roof an illustrative form of slot exit jet is disclosed in Fig. 3. In this purely illustrative form the roof 21 leads to a rain water trough 34 having an upstanding leg 35 in such position as to catch rain water or melted snow flowing down roof 21 to conduct it off in the usual manner. The main spout is preferably faired into the wall 17 as by a strip 36 to cause a smooth flow. The eave 23 carries a water or rain trough 37 having an upstanding leg or wall 38 sloping downwardly and upwardly terminating in the rounded lip 40 spaced from the wall 17. The eave 23 may also carry a lower-most rain spout 41 if desired.

The walls 36 and 38 define the slot 26 in disposition such that stagnation pressure of the air against the wall 17 is substantially converted into high velocity jet flow through the slot for the purpose described.

A further modification of the structure schematically indicated in Fig. 3 is indicated in Fig. 4, the primary change of which is the provision of a construction of the side wall 35 of the first mentioned rain trough downwardly into the Venturi wall 42 leading into the wall 17. The other parts are the same except the rain spout 37 is shortened in one wall so that the extension 38 forms the other Venturi surface of the throat or venturi 43 leading through the slot 26. It is preferred that the side wall 35 of the rain trough 34 be inclined at a slight angle relative to the wall 17 so as to direct the jet into a line more nearly normal to the roof portion 21 than might maintain if the wall 35 were parallel to wall 17. It will be understood that the passage of the stagnation pressure vertically through throat or Venturi slot 43 is marked by a great acceleration and a relatively thin sheet of air is projected at high velocity in a line of such angular divergence from the roof as to cause sufficient turbulence in the flow over the roof as to preclude disastrous reduced pressures thereover.

It will be clear that the throat or slot through which the air accelerates in the jet emission described will be shaped as best to secure the desired slot action and to this end many contours and formations will be available. For purely illustrative purposes a few additional constructions are indicated in Figs. 5–9 inclusive.

In the modification schematically disclosed in Fig. 5 roof portion 21 has a rain or a water trough 44 the upward wall 45 of which forms one surface of the slot exit jet 46 while an upstanding fin 47 mounted on the eave 23 forms the cooperating wall of slot 26 and the air traveling up wall 17 will be projected through slot 26 with enhanced jet velocity.

In the schematic illustration of Fig. 6 the roof 21 terminates in a rain or water trough 48 the side 50 of which is engaged by a throat-forming fairing fin 51 having a free end 52 extending above the level of the roof 21 and with the inner end curving into wall 17 to define one surface of the Venturi slot 53. The other surface of slot 53 is formed by a fairing 54 curved reentrantly to project toward the eave 23 as at 55 and having a free end 56 also projecting above the level of the roof 21. The slot 53 thus defined is one of reduced friction and of positive projection into the stream flowing over the roof 21 substantially parallel thereto.

It is important to observe of Figs. 5, 6 and of Fig. 8 to be described that the synthetic spoiler or turbulence creating jet discharge as a spoiler entity is combined with a physical spoiler comprising a surface projecting above the roof level in position to interfere with the flow. This is another phase of combination spoiler in which the two spoilers, namely the fixed physical projection and the variable synthetic projection comprising the flowing air stream are associated in contiguous combination whereas in the disclosure of Figs. 1 and 2 the air jet 26 may be spaced from the physical barriers or spoilers 27 or 30. Obviously, if desired, all may be combined in one roof.

A very simple form of synthetic spoiler is disclosed in Fig. 7 in which the roof portion 21 terminates in a depressed rain trough or gutter 57 the upstanding wall 58 of which merges into a fairing 60 leading toward wall 17 analogous to the disclosures of either Fig. 3 or 4. The cooperating surface 61 comprises a mere fin and not an eave but disposed in such convergent spaced relation to the fairing 60 and wall 58 as to define the upwardly projecting slot exit 62.

A still simpler form is indicated in Fig. 8 in which the roof 21 terminates in a slot 63 substantially in line with wall 17 while the eave 23 thereof carries on its upper edge the upstanding curved fin 64 defining with the edge of roof 21 and wall 17 the slot 63. As noted the fin 64 comprises a spoiler regardless of the fact that air passing along the upward side thereof in the jet of high velocity comprises a contiguous spoiler.

A form which may be used although not being preferred is illustrated schematically in Fig. 9 in that roof 21 terminates in line with wall 17 substantially while the space for a short interval below roof portion 21 is recessed as at 65 to form one curved surface of the slot exit jet 66. A complemental fin 67 is positioned as to define with the recess 65 in the wall 17 the high velocity jet exit 66. Obviously the recess 65 can be associated with any of the earlier mentioned forms of invention if this should be desired for any purpose, although obviously this is a more expensive and more difficult type of construction than those described so far.

A further modification is indicated in Fig. 10 and 11. Again this is a more expensive type and is not preferred, but under certain conditions may be available. In order to indicate the fact that this invention is applicable to any type of roof the schematic diagram of Fig. 10 shows a structure in the nature of a hangar comprising side walls 68 and 70 and a curved roof 71 which need not have eaves although these may be used if desired. The roof 71 which may replace the angular divergent plane sided roofs of any of the earlier figures, may have a pair of physical upstanding spoilers 72 to augment a slot or jet emission as described and at points spaced from the edge, inwardly of the side walls is provided with jet exit slots 73. The latter are in communication with the divergent surfaces of a duct having an enlarged mouth 74 in the side walls 68 and 70 respectively and having the lower inner surface 75 and the upper short surface 76. It will be understood that the entry of air into the mouth 74 under the stagnation pressure developed by impingement against the wall 68 may be enhanced by the provision of upwardly and outwardly arranged fins or eaves 77. The effect of the slots 73 may be considerably enhanced by positioning the slots inwardly of the side walls as shown in Figs. 10 and 11 rather than at the outer line of the building as in the earlier figures, and the provision of properly shaped conduits at strategic points having their jet exits at appropriate discharge points may represent a very effective definitely predeterminedly turbulence creating means.

The basic intention of the invention is to convert energy developed by pressure against the sides of a building into a predeterminedly angularly disposed high velocity sheet or jet of air so as to secure a predetermined resultant turbulence in the air flowing over the top of the building to prevent unroofing differential pressures on the roof of said building. Obviously the mode or means for converting pressure energy into a spoiler are subject to wide ramifications and such are to be construed as within

the scope of this invention unless otherwise specifically limited in the claims hereinafter recited.

I claim as my invention:

1. In building constructions comprising a substantially vertical surface and a roof extending laterally of said vertical surface, nozzle jet exit slot means having an intake opening located in the substantially vertical surface, and having a restricted exit opening located operatively relative to the roof for converting free wind stagnation pressure energy against said substantially vertical surface into a high velocity air discharge jet angularly divergent from and beyond said roof so as to secure substantially predetermined turbulence in the air stream blowing over said roof.

2. In building constructions a plurality of substantially vertical walls defining a building, a roof enclosing the building, slot means operably associated with said roof and with the respective side walls, said means comprising an intake opening in each side wall communicating with a restricted slot exit opening operably disposed in the roof so as to convert pressure-energy of free wind incident on a vertical wall into a turbulence creating jet emission of high velocity air flow transversely of the flow of air passing across said roof regardless of the angle at which wind strikes the building and regardless of the vertical surface upon which it impinges.

3. In building constructions a roof, means operably associated with the roof to create a predetermined degree of turbulence in air flowing over the roof to prevent unroofing differential pressures internally and externally of the roof, part of said means comprising a jet exit slot having an entrance opening in communication with the area of stagnation pressure arising from the impingement of free wind again the building construction and having an exit slot opening of restricted area relative to the entrance in communication with the air above the roof for converting such pressure into a stream of high velocity air and projecting same transversely of the flow over said roof.

4. In building constructions a roof, means operably associated with the roof to create a predetermined degree of turbulence in air flowing over the roof to prevent unroofing differential pressures internally and externally of the roof, part of said means comprising a jet exit slot having an entrance opening in communication with the area of stagnation pressure arising from the impingement of free wind against the building construction and having an exit slot opening of restricted area relative to the entrance in communication with the air above the roof for converting such pressure into a stream of high velocity air and projecting same transversely of the flow over said roof, another part of said means comprising a fin-like device extending above the roof and disposed in such relation to the exit slot as to enhance flow through the slot by lowering pressure over said slot exit as air flows over the roof.

5. In building constructions a roof, means operably associated with the roof to create a predetermined degree of turbulence in air flowing over the roof to prevent unroofing differential pressures internally and externally of the roof, part of said means comprising a jet exit slot for projecting a stream of high velocity air transversely of the flow over said roof, another part of said means comprising a fin-like device extending above the roof, said last two mentioned parts being contiguous one to the other.

6. In building constructions a side wall, a roof terminating at the side wall and a rain trough mounted on the side wall, fairing means associated with the rain trough and said wall defining a throat for a venturi slot, fin-like means mounted in spaced relation to the fairing and complemental thereto and defining therewith a convergent slot for converting static pressure against said wall into high velocity air flow through said slot divergent from said roof.

7. In building constructions a side wall and roof, means defining a substantial venturi slot the exit of which is adjacent to the roof in position to direct a high velocity stream of air transversely of the roof as a resultant of wind pressure against the side wall.

8. In building constructions a side wall and roof, means defining a substantial venturi slot the exit of which is adjacent to the roof in position to direct a high velocity stream of air transversely of the roof as a result of wind pressure against the side wall, a portion of the means defining the slot projecting above the adjacent roof level.

9. In building constructions a side wall, a roof, a duct having an enlarged opening in the side wall terminating in a restricted slot in the roof for converting pressure against the side wall into high velocity discharge through the roof into the air stream over the roof, said duct being out of communication with the interior of the building construction.

CHARLES TOWNSEND LUDINGTON.