Oct. 16, 1956 D. SILVERMAN 2,766,677

FLUE CONTROL DEVICES ADAPTED FOR COMBUSTION HEATERS

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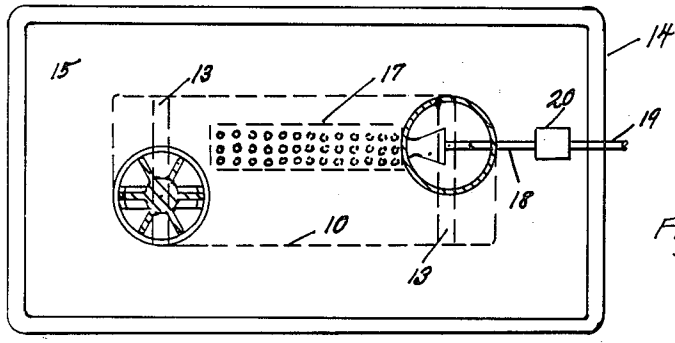


Fig 2.

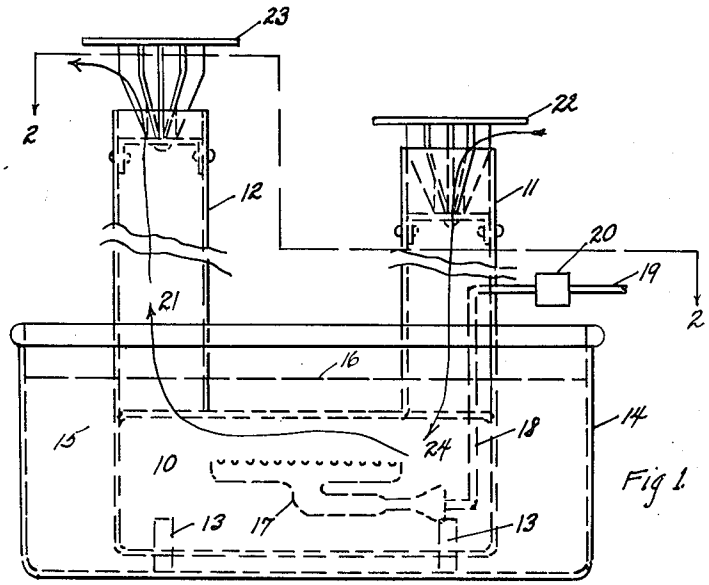


Fig 1.

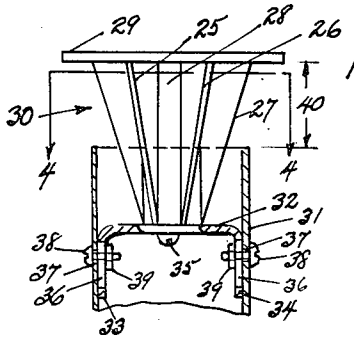


Fig 3.

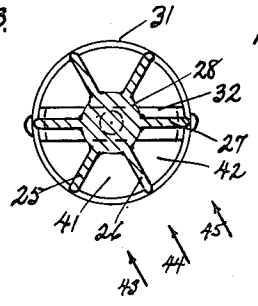


Fig 4.

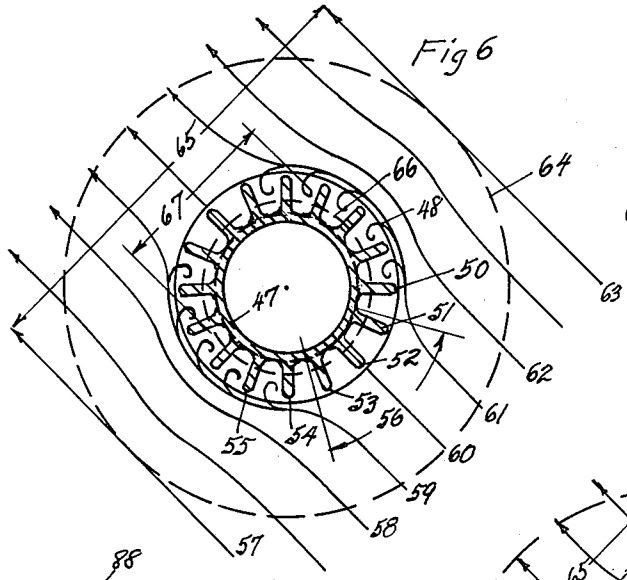
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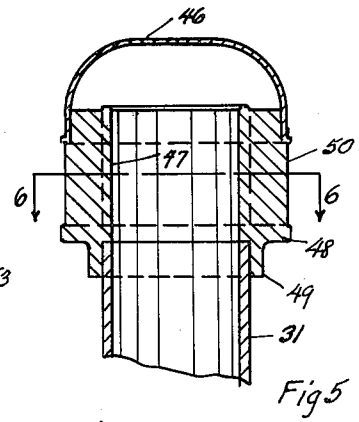
Daniel Silverman

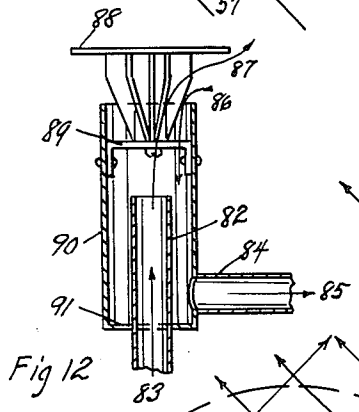
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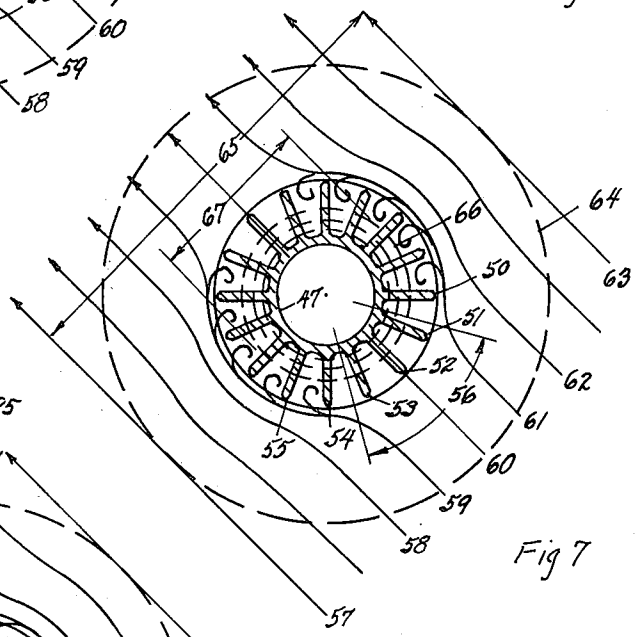
FLUE CONTROL DEVICES ADAPTED FOR COMBUSTION HEATERS

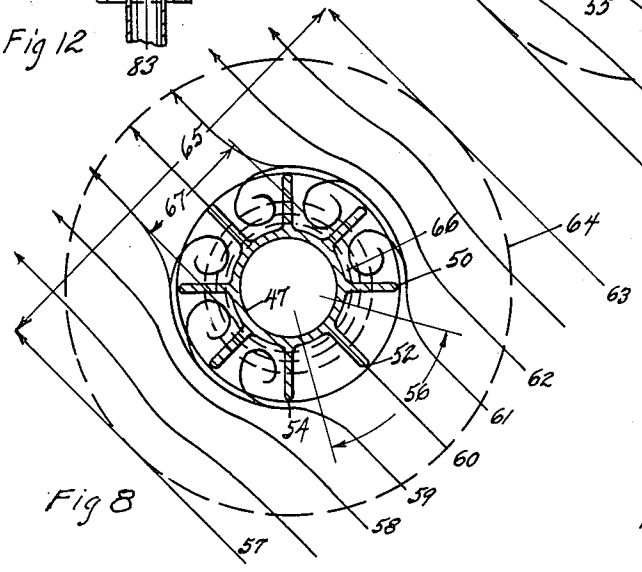
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INVENTOR.

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FLUE CONTROL DEVICES ADAPTED FOR COMBUSTION HEATERS

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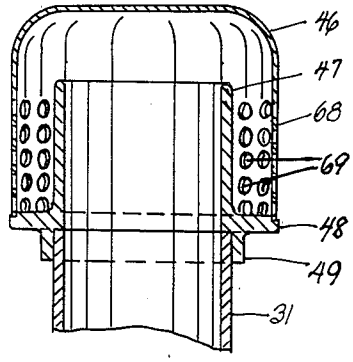


Fig. 9

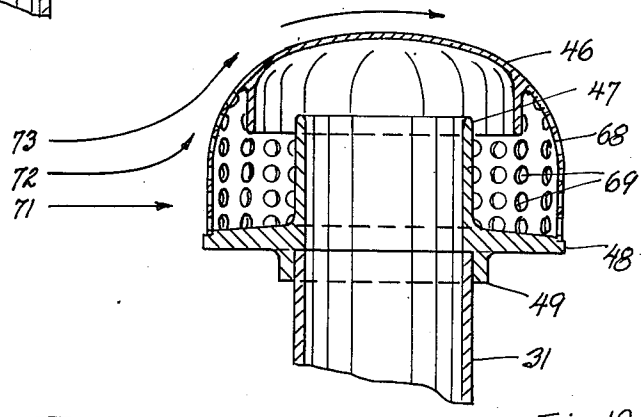


Fig 10

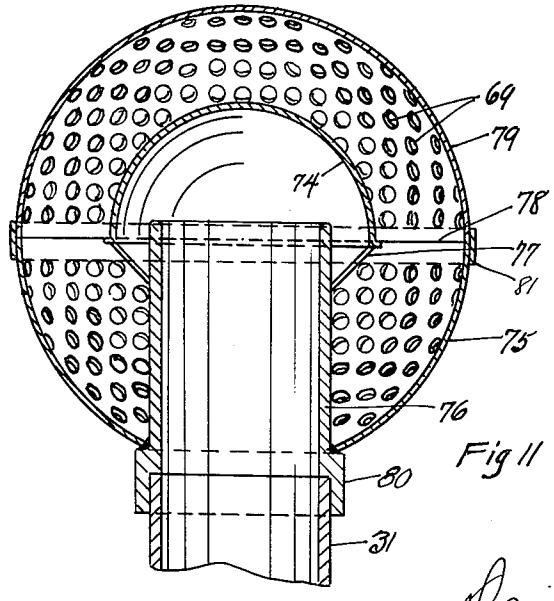


Fig 11

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FLUE CONTROL DEVICES ADAPTED FOR COMBUSTION HEATERS

Daniel Silverman, Tulsa, Okla.

Application July 21, 1950, Serial No. 175,249

1 Claim. (Cl. 98—62)

This invention relates to the design of stationary omnidirectional flue or ventilator pipe caps or terminations, in relation to the type of pressure or suction effect induced in them by action of the wind. It is directed particularly to the control of pressure and/or suction effects so as to provide a type of termination which gives a positive pressure, a suction or a neutral effect, as desired, independent of the direction of the wind.

Numerous occasions arise when it is necessary to provide a flue, ventilator pipe or conduit from the inside of a closed structure, such as a house, shielded from the wind, to the outside of that structure where such pipe is in the path of the wind. In blowing around and over the end of the pipe projecting from the structure, the wind may induce a suction effect, as when the structure is to be ventilated and a circulation of air through the structure and out through the pipe is desired. Such is the case also when the pipe is the termination of a gas or oil burning appliance and the pipe is provided for the purpose of carrying to the out-of-doors, the products of combustion of the appliance. At other times it may be desired to provide a pressure effect to induce an airflow down the pipe into the structure.

In cases where a suction effect is desired it may be particularly objectionable, or even disastrous, to have a pressure effect. For example, when there is a pressure or blow-back effect of the wind, the flame of a gas burning appliance may be extinguished, with resulting danger to the occupants of the structure in which the appliance is installed. To safeguard against such back pressures, there are attachments called draft hoods, or down draft diverters, connected between such appliances and their flue pipes, which provide a by-pass opening so that pressures in the flue pipe are relieved to the room atmosphere, without creating a back pressure in the combustion chamber of the appliance. These draft hoods are not only wasteful of heat, since they carry out of the room and to the outside atmosphere a constant stream of warm air, but they permit the leakage back into the room of poisonous products of combustion that may be blown back due to the back pressure induced into the flue pipe by the wind.

There are also gas burning appliances that are self-contained and installed entirely out-of-doors, such as submergible heaters for stock tanks, or other types of outdoor appliances. In the combustion chamber of such appliances there are at least two openings, through one of which is admitted to the burner the combustion air, and through the other of which the products of combustion are carried out of the combustion chamber. Both of these openings are acted upon by the wind and the resultant effect on the passage of air through the combustion chamber and attached pipes is the resultant of the pressure and/or suction effects on both of the openings.

While this type of pipe termination is best known in connection with the flow of, and the effects of wind, there are also appliances and applications where other gases or liquids are involved, as when a side pipe is introduced into a larger pipe or conduit, in which water, oil or other liquids might be flowing. Such applications are considered to be within the scope of this invention, and when I speak in general terms of "fluid" flow, I mean the flow of liquids and/or gases.

A general object of my invention, therefore, is a novel and improved method and apparatus for control of the pressure and/or suction effects on the openings of a chamber immersed in a fluid, due to the flow of fluids across said openings. One specific object of the invention is the control of the pressure and/or suction effects on the inlet and/or exhaust pipes of a combustion chamber, due to the flow of air across such pipes. Another object of my invention is a rigid omnidirectional flue or ventilator pipe termination in which a suction effect is provided by wind blowing across it, without the possibility of back pressure, no matter what the magnitude or direction of the wind. Another object is a type of pipe termination which may be exposed to the wind and in which a positive resultant pressure is created by the wind blowing across the termination. Another important object of this invention is a flue termination in which the pressure and suction effects are substantially compensated for all directions and magnitudes of wind velocity. Another objective is a type of termination which may be applied to the openings of a chamber immersed in a fluid, which create a balance so there is substantially no flow of fluid through the chamber when the terminations are subjected to substantially the same flow of fluid. Another important object of this invention is an improved tank heater in which a positive direction of flow air through the combustion chamber from inlet to outlet, without possibility of reversal, is provided irrespective of the magnitude or direction of the wind. Other objects, uses and advantages of my invention will become apparent as the description proceeds.

Stated generally, my invention for control of the pressure and suction effects induced by a fluid flowing across a conduit termination, comprises the provision of a multiplicity of similar elements distributed circumferentially, and exposed to the fluid flow. Those elements within a certain angle facing the direction of the fluid flow, are pressure-generative. Those elements in the remaining portion of the structure, to the sides and to the rear (as seen from the direction of flow) are suction-generative. By proper design of the contour of the surface of these elements a greater or lesser pressure effect, and a lesser or greater suction effect can be generated. Since the pressure-generative effect of the elements on the leading surface of the termination tends to compensate the suction-generative effect of the other elements, the resultant effect can be a pressure or a suction, or a substantially complete neutralization, depending upon the relative magnitudes of the two effects.

This will be better understood by reference to the accompanying drawings forming a part of this application, and illustrating certain embodiments of the invention. In these drawings;

Figure 1 is an elevation view of a submergible tank heater equipped with terminations designed according to my invention;

Figure 2 is a sectional view of the heater of Figure 1 taken along the broken line 2—2;

Figure 3 is an elevation view of one embodiment of my invention;

Figure 4 is a horizontal section taken across the plane 4—4 of Figure 3;

Figure 5 is a vertical section of another embodiment;

Figures 6, 7 and 8 are three horizontal sections taken along the plane 6—6 of Figure 5, showing three variations of vane width and spacing;

Figures 9, 10 and 11 are vertical sections of three

variations of design of high suction terminations according to the teachings of my invention. All three are designed with circular symmetry; Figure 9 being substantially cylindrical; Figure 10 substantially hemispherical; Figure 11 substantially spherical in shape; and

Figure 12 is a vertical section of another embodiment of my invention.

Referring now to the drawings and particularly to Figures 1 and 2, a self-contained heater is shown, which is designed for submergence in a tank of water, such as drinking water for farm stock, in order to prevent freezing of the water in cold weather. It comprises a combustion chamber **10** with two vertical pipes, one, **11**, for the inlet air, and the other, **12**, for the outlet flue gases, the latter rising above the former so as to provide natural draft. The unit rests on feet **13** in a tank **14** filled with water **15** to the level **16**. The water is heated by convection, as heat is transferred through the walls of the chamber **10**. A burner **17** is supported on pipe **18** and fed with hydrocarbon gas through pipe **19** from a source not shown, and controlled by valve **20**. Flame **21** issues from the burner, and by contacting the wall of the combustion chamber transfers heat to it and to the water surrounding it. The spent gases travel up the pipe **12** and out through the termination **23**. The inlet pipe **11** through which entering air **24** flows, is capped by a termination **22**.

In a combustion device of this sort it is important that a continuing supply of fresh air be provided for combustion through the inlet pipe in spite of what the effects of the wind might be on the two openings of the combustion chamber which are exposed to the wind. A reverse draft will cut off the supply of air and will smother the flame in the atmosphere of the flue gases. Once the flame is out it will not reignite even though the direction of flow of air is reversed to its original proper direction.

In order to insure that the flow of air through the combustion chamber is not reversed, I have found that it is necessary to use two terminations **22** and **23** on the two pipes **11** and **12** respectively. The termination **22** on the inlet pipe **11** is positively pressure-generative when exposed to the wind. The termination **23** on the flue pipe **12** is positively suction-generative when exposed to the wind. Under these conditions it is impossible to have a reversal of flow of air through the system, particularly when the two openings are exposed to substantially the same conditions of wind flow. It will of course, be obvious that in order to have an efficient heater it is important that the pressure-generative termination create only a moderate pressure, being positive that no suction effects occurs. Also the suction-generative termination, while positively suction-generative, must not create a high suction. To have a high suction and/or a high pressure will cause too large a flow of air through the heater and thus reduce its efficiency.

The heater may be made from sheet metal, pipe sections or may be cast in the desired shape, as is well known in the art. This invention is concerned not so much with the construction of the heater itself as with the type of pipe terminations used. The two terminations **22** and **23** of Figure 1 are substantially similar units, differing primarily in operating adjustment. They are similar to the unit shown in Figure 3 and Figure 4 and their principles of operation will be described in connection with those figures.

In Figure 3 is shown an elevation view of one embodiment of my invention. It comprises an assembly of substantially identical vanes arranged in a symmetrical pattern of intersecting planes. In special cases, such as the one shown in Figure 3, the vanes may be radial and longitudinal, and all may intersect along the axis of the termination or along the surface of a central core. However, these limitations are not necessary. The vanes may be arranged in other than radial planes, and may be inclined to the longitudinal axis, provided all vanes are symmetrically arranged in a similar manner. While any number of vanes may be used, I prefer to use at least 4 or 6 so that the action of the termination will be reasonably independent of the direction of the wind. In Figures 3 and 4 I have shown 6 vanes. They are indicated as **25**, **26**, **27**, etc. They are formed of sheet material and assembled as shown, or they may be cast or molded of metal, plastic or the like.

It is preferred that a cylindrical core **28** be provided as shown. One purpose of the core is for strength of construction and convenience in mounting. Another purpose, as will be explained in detail in connection with Figure 5 is to control the depth of the channels between vanes. I have found that the depth of the channels, in conjunction with the number of vanes (or the circumferential spacing of the vanes) determine the amount of pressure and/or suction generated by the fluid flow around the vaned structure. It will be clear that the central core **28**, except for the matter of supporting the termination as shown in Figure 3, can be hollow, to allow fluid flow through the core to another termination structure mounted above the cap **29**, or for other reasons. Also the core **28** can be of any desired diameter, and can be cylindrical or conical, to provide for variable or constant depth of the channels between vanes.

The vanes are all of substantially similar shape and size, and may be triangular or trapezoidal in shape, tapering in width in the direction away from the cap **29**, for the purpose to be described below. The upper portion of the vanes can be tapered, or substantially constant in width as shown in Figure 1. A top plate, cap or cover **29** is provided to protect the top edges of the vanes against the flow of fluid. Only the outer edges of the vanes are exposed to the flow of fluid. The cap or cover **29** may, if desired, be of larger diameter than the vane assembly in order to act as a rain shield.

In the design of an omnidirectional termination, I prefer to provide substantially circular symmetry in the termination of fitting itself, and in the part of the pipe or conduit with which it is to be used. In use, the fitting, crown or termination, generally indicated as **30** in Figure 3, is partially inserted into the open end of the conduit **31**. The termination may be supported in any way desired, but is preferably supported from below, so that the supporting members will not be acted upon by the fluid flowing around the termination. One such method of support is indicated, by way of example, and comprises a horizontal bar **32** with down-bent portions **33** and **34**. Midway between the bends is a hole through which a screw **35** is inserted and screwed into a cooperating tapped axial hole in the lower portion of the vaned assembly **30**. The supporting bar **32** may be curved and of a springy nature so that it can be moved up and down in the pipe, for reasons which will be made clear below. Or if a more permanent fastening is required, vertical slots **36** may be provided in the down-bent portions **33** and **34** and corresponding holes **37** provided in the walls of the conduit **31**. Screws **38** and nuts **39** will then serve to hold the bar in any desired position. Thus it is possible to position the termination in the open end of the conduit with any desired spacing **40** between the cap **29** and the top edge of the conduit **31**.

In Figure 4 is shown a horizontal section taken along plane 4—4 of Figure 3. Vanes **25**, **26**, **27**, etc. are shown, with channels or pockets **41**, **42**, etc. therebetween, as indicated. For purpose of discussion, consider the case where the termination is used on a vertical conduit exposed to a flow of air. A stream of air is shown blowing across the termination, with arrows **43**, **44** and **45** indicating their direction. I have found that in the channels **41** and **42** in the direct path of the air there will be a pressure built up due to the stream of air. Since the upper ends of these channels are closed off by cap **29**, this pressure will be reflected downward into the open end of the conduit. The side streams of air flow around

the sides of the termination and over the open end of the conduit. When a stream of air flows across an open end of a pipe, transverse to the axis of the pipe, a suction is generated. However, I have arranged that the central portion of the conduit is obstructed by the vaned structure so that only a portion of the open end of the conduit is exposed to the transverse flow of air. Since the amount of suction generated is a function of the size of the opening, the smaller the opening, the less the suction.

Thus there are two opposing effects in action. When the spacing **40** is large, that is, when the narrow end of the vanes are exposed at the top edge of the conduit, the pressure effect will be small. At that time, the exposed end of the conduit is large, and the suction effect is large. Since these two effects tend to compensate each other, the suction effect will generally be greater than the pressure effect for this condition, and a resultant suction will exist in the conduit, causing a flow of air upward in the conduit. When the termination is inserted farther into the conduit, so that the spacing **40** is smaller, the vanes will be wider at the top edge of the conduit, creating a greater pressure effect. At the same time there will be less open area of the conduit exposed, and so there will be less suction effect. If the spacing is reduced to a small enough value, the resultant effect will be a pressure induced into the conduit. There will thus be a flow of air down the conduit. I have shown how, with only the narrow end of the vaned structure **30** inserted into the conduit, a resultant suction effect is obtained. This corresponds to the adjustment of the termination **23** on the exhaust pipe **12** of the tank heater of Figure 1. On the other hand, when the vaned structure **30** of Figure 3 is inserted farther into the conduit **31**, a point is reached where the effect of air flow over the termination is to create a resultant pressure effect. This is the condition of adjustment required for termination **22** on the inlet pipe **11** of Figure 1. Thus, by adjustably inserting the vaned structure **30** to different depths in the end of the conduit, I can create a resultant pressure of suction effect as desired. It will be obvious from the above description of the principles of operation, that at an intermediate depth of insertion of the vaned structure there will be a substantial compensation of pressure and suction effect so that the resultant effect of the wind blowing across the termination will be to generate neither pressure nor suction.

The maximum pressure effect will occur when the vaned structure **30** is inserted to a minimum spacing **40**, where the diameter of the vanes is substantially equal to the inner diameter of the conduit. The portion of the vanes exposed between the edge of the conduit **31** and the cap **29**, over the edges of which the air stream flows, can either be tapered, as are the lower portions shown in Figure 3, or they can be cut substantially cylindrical, as is shown in the case of terminations **22** and **23** of Figure 1.

In the case of the embodiment of my invention shown in Figures 3 and 4 I have shown how it is possible to provide a termination which will create either a pressure or a suction effect when exposed to the wind, dependent only on the depth to which it is inserted into the conduit. In another embodiment of my invention I have found that it is possible to vary the design of the termination in a different way to provide either a pressure or a suction effect. In particular, I provide a symmetrical arrangement of outwardly extending vanes which are exposed to the transverse flow of fluid. The longitudinal channels between the vanes communicating with the interior of the conduit are the only means of communication between the interior of the conduit and the flowing air or other fluid. By choice of the number of vanes or the circumferential spacing between them, and the depths of the channels therebetween, the type of pressure or suction effect induced by fluid flow across the termination can be predetermined. This will be shown in connection with Figures 5, 6, 7 and 8, which show different views of my preferred embodiment.

The termination is shown in Figure 5. It comprises generally a tubular member **47** attached to an annular plate **48** and a multiplicity of equally spaced outwardly extending vanes **50, 51, 52, 53, 54, 55**, etc. attached to the members **47** and **48**. A subsidiary tubular section **49** may be provided for the purpose of attachment (by means not shown) to the conduit **31**. A cap or cover **46** is provided to close off the end of the assembly opposite to the annular plate **48**. Figure 6 is a cross-section of the structure of Figure 5 taken along plane **6—6**. Figures 7 and 8 are variations of Figure 6 to illustrate special conditions. This type of structure is generally disposed across the flow section of the conduit. It is desirable, but not essential that flow cross-sections throughout the termination be kept the same as that of the conduit.

Omnidirectional terminations, both pressure- and suction-generative have been made in the form of rotating structures. These are not satisfactory for use on flues connected to gas combustion appliances. Momentary surges of air in a reversed direction are sufficient to extinguish a gas flame, whereas the duration of such surges may be so short as to make the rotating structure unresponsive. Furthermore, in cold weather rotating units are subject to stoppage by icing up, and unless they are properly maintained they fail to rotate as required. It is clear therefore, that the ideal solution for a termination for gas combustion appliances is provided by a stationary, rigid, non-rotating, omnidirectional termination.

By the designation "termination" I mean to include not only separate unitary structures which may be attached to, supported by or inserted into pipes or conduits, but also those pipes or conduits which are shaped in accordance with the teachings of my invention, and in which the termination is built into and is part of the conduit itself.

In Figure 6 is shown one possible configuration of the embodiment of Figure 5. Choice of the number and/or spacing of the vanes, and the depths of the channels is an important consideration in the design of these terminations. As in the case of Figure 3, the vanes need not be radial or longitudinal. They should, however, be in symmetrically arranged circumferentially disposed intersecting planes. For convenience I have shown them as radial and longitudinal. In Figure 6 is shown numbered vanes **50, 51, 52, 53, 54, 55**, etc. in the portion of the unit facing the direction of flow of fluid, which, in general terms is any gas or liquid. In this case the fluid will, for convenience, be considered as air.

I have discovered that the air is directed into the channels on the leading face of the termination is brought to rest, and a pressure is built up in these channels. The pressure-generative area on a cylindrical surface depends upon the character of the surface and the particular fluid under consideration. For practical purposes it may be considered as extending 30 to 40 degrees on either side of the axis of symmetry. This pressure-generative region is indicated generally as **56**. Streamlines **57, 58, 59, 60, 61, 62** and **63** are shown in the body fluid flowing across the termination. Streamline **60** is directed along the axis of symmetry. Streamlines **59** and **61** are directed to either side of the cylindrical outline of the termination. If the cylindrical contour of the surface were smooth, the fluid flow along the surface would be streamlined and high velocity. This velocity is higher than the average velocity of flow in the main body of fluid ahead of the obstruction offered by the conduit. This higher velocity is the cause of a lowered pressure in the high velocity layer along the surface. This causes a suction to be generated in the openings of the termination in contact with the flowing fluid.

If the cylindrical contour of the termination is not perfectly smooth, but constructed with ridges or obstructions such as the vanes **50, 51, 52**, etc. there will be some turbu-

lence in the channels between the vanes. Portions of the air flowing in the streams 59 and 61 will spread out and curl around the edges of the vanes and will cause turbulent motion in the channels. Thus the velocity of the streamlines closest to the contour of the termination will be reduced, and there will be a lesser suction generated by the flowing fluid in the openings of the termination.

If the group of streamlines 57 to 63 are followed in their course, beginning some distance ahead of the termination, it will be observed that the entire volume of air is compressed into a smaller space, which is the space between the maximum diameter of the termination and the streamlines 57 and 63. These streamlines 57 and 63 are chosen as those which mark the boundary of the region of flow disturbed by the obstruction. In order for this larger volume of air to pass through this space, a portion of it, particularly that close to the termination surface, will be moving at higher velocity, and thus the pressure in the stream at that point will be reduced and a suction generated. The greater the confinement, the greater the suction effect.

The positions of the streamlines 57 and 63 are a function of the maximum diameter of the termination, in this case, the diameter of the edges of the vanes. Assume that the maximum diameter is held constant and the smooth contour is removed by creating channels, pockets or flutes into which the flow can expand. In effect, the width of the area of confinement is expanded, thus reducing the velocity of the air passing through this region. Furthermore, this widening of the flow area has taken place in the immediate vicinity of the high velocity portion of the stream. Thus the type of surface contour shown in Figure 6 is effective in reducing the suction generated at the surface of the termination.

In Figure 7 is shown a slight variation of the structure of Figure 6. This variation is in the diameter of the tubular element 47. The same number of vanes is shown, and the same streamlines 57 to 63. As in the case of Figure 6, the inner streamlines 59 and 61 curl around the edges of the vanes and cause a turbulent flow. However, while the channels between the vanes are deeper in Figure 7, they are quite narrow, and there is no opportunity for the turbulence to spread into the bottom portion of the channels. The bottoms of the channels are thus not effective in increasing the turbulence.

On the other hand, in Figure 8 is shown another variation, in which the diameter of the cylindrical element 47 is the same as in Figure 7, that is, less than that of Figure 6. But in addition, alternate vanes have been removed, which makes channels between vanes which are both wider and deeper in Figure 8 than in Figure 6. With the greater width and depth of the channels, there is greater turbulence, and thus a lesser suction effect. In Figure 8 areas of confinement of the flowing stream are widened to a greater extent than in the other two figures. Thus, I can state, that the greater the numbers of vanes (or the smaller the spacing between vanes) or the shallower the depth of the channels, the greater the value of the suction generated.

The streamlines 57 and 63 mark the boundary of the zone of disturbance in the fluid body. A circular area concentric with the conduit and of diameter equal to the distance between the streamlines 57 and 63 is designated for convenience as the maximum area of disturbed fluid. It is shown in Figure 6 as a dotted circle 64 of diameter 65. There is also an area defined by a circle concentric with the conduit and lying within the outer diameter of the termination, which is the minimum area of disturbed fluid. It is designated as 66 and its diameter as 67. The ratio of the diameter of maximum area of disturbed fluid to the diameter of the minimum area of disturbed fluid is a measure of the suction generated. The deeper and wider the channels between vanes, the farther the turbulence progresses inward toward the center of the termination, and the higher the ratio of diameters of maximum to minimum areas of disturbed fluid. The ratio

can be changed by varying either of the two diameters. For example, by keeping the same outer diameter of vanes, the diameter 65 of the maximum area of disturbance is held constant. By varying the depth and circumferential width of the channels the diameter 67 of the minimum area of disturbed fluid is changed and thus the ratio of the two diameters is altered. Conversely, if the diameter of the inner cylindrical element 47 is held constant and the vanes are of wide enough spacing, the diameter 67 is held substantially constant. Now if the vanes are increased in diameter, the maximum area of disturbed fluid will be greater and the ratio of the two diameters will be greater.

I can make some approximate generalizations regarding the dimensions of the terminating fitting which will create an overall pressure- or suction-generative effect. For example, for a conduit of diameter 4 inches, I find that a termination of the type of Figure 3 or Figure 5, with from 6 to 12 thin vanes will show an overall pressure effect. If the number of vanes is greater than about 25, the unit will be suction generative. The wider and deeper the channels between vanes, the greater the overall pressure effect. Thus, for a pressure termination, I prefer to make the circumferential width and radial depth of the channels both of the order of 0.5 to 1.0 times the radius of the conduit or the radius of the outer edge of the vanes, whichever is the greater. For a suction termination, I prefer that either the circumferential width or the radial depth, or both, be in the range of 0.05 to 0.2 times the radius of the conduit, or less. For a pressure termination, I prefer that the circumferential width and the radial depth of the channels both be at least one inch or greater, while for a suction termination either the circumferential width or the radial depth should be less than 0.5 inch.

These relationships are based upon a hypothetical flow of fluid in a direction perpendicular to the axis of the conduit or pipe. Actually, most flow of fluid in the open is far from constant in direction. In the flow of the wind, for example, there are eddies and other forms of turbulence always present to a certain degree. Thus, while I speak of a transverse flow of air (or other fluid), which technically means a flow perpendicular to the axis of the conduit, I mean a flow, which, while generally perpendicular, can vary from this direction through a rather wide angle. In terms of wind flow, I recognize that there are up-drafts and down-drafts always present in a wind which nominally flows transversely to a vertical pipe or conduit. The dimensions specified in the preceding paragraph apply as well to the vanes and channels across the flow of the up- and down-drafts, just as they do the longitudinal vanes and channels across the flow of the transverse wind. The optimum arrangement of vanes, channels, ports, or other flow directing openings, provides for equal dimensions in the longitudinal and transverse directions. However, this ratio is not too critical and may vary through a considerable range.

It will be obvious to one skilled in the art that the assembly shown in Figure 5 and without the annular plate 48 can be combined with the assembly of Figure 3 without the cap 29. Or, if desired, the annular plate 48 and the cap 29 can be made coincident. The two assemblies are placed together so that the vanes of Figure 3 are extensions of the vanes of Figure 5 in a downward direction. This would correspond to the case where the central core 28 is large enough to have a central hole along its axis equal in diameter to that of the tubular member 47. Thus, this vaned assembly would be provided with an axial hole throughout its length and would be inserted at its lower end into the top opening of the conduit, and would be inserted at its top end into a short cylindrical cup. The cup and the conduit would be of substantially the same diameter and equal to the maximum diameter of the vanes.

In Figures 5, 6, 7 and 8 I have shown views of a preferred embodiment of my invention. It is a stationary

rigid omnidirectional termination which can be adapted to be pressure-generative or suction-generative. Furthermore, it is a type of termination that prevents the entry of rain or snow into the conduit since the lower edge of cap 46 is below the level of the top edge of the cylindrical portion 47. Furthermore, because of the vanes, the cross-section for fluid flow from the inside of the conduit to the outside is broken up into small channels which prevent the entry of small birds or animals. The cap 46 presents a streamlined surface roughly flush with the outer diameter of the vanes, although this is not a required condition. For fluid flow over the termination in a longitudinal direction the spacing between the lower lip of the cap 46 and the top edge of the annular plate 48 serve to control the character of flow. This dimension should preferably be of the same order of magnitude as the circumferential spacing between vanes.

For uniform area of cross-section for fluid flow through the termination, the outer diameter of the cap 46 will be of the order of 1.4 times the diameter of tube 47, or 1.4 times the diameter of the conduit 31. The vertical dimension of the openings will be of the order of 0.2 times the radius of the conduit. In the case of large diameter high suction terminations in which a close spacing of vanes is required, it may be necessary to place around the outer edges of the vanes narrow cylindrical straps, rings or thin annular plates, spaced uniformly between the edges of cap 46 and annular plate 48. By this means, the total opening is broken up into a multiplicity of small square or round openings of small enough dimension to provide a minimum of turbulence to fluid flow around the termination. This is the condition desired for high suction.

In Figure 9 I have shown a modification of Figure 5 which is particularly adapted to be highly suction-generative. In this design I have carried the cap 46 down until it abuts the annular plate 48 by extending a perforated skirt 68. The perforations 69 are in the area of the skirt which is below the top edge of 47. Because only a fraction of the area of the skirt is open, it will be found in general that the vertical extent of the perforated zone will be greater than the vertical dimension of the opening in Figure 5. The perforations are preferably circular, although rectangular perforations of small dimension may be used. Also, the bottom row of perforations should be so placed as to effectively drain the space behind the skirt, and for this purpose the annular plate 48 may be slightly sloping downward and outward. With the small openings in the skirt, there is little turbulence generated in these openings by the flow of fluid around the termination. Since this turbulence does not penetrate into the interior of the skirt 68, it is possible to remove the vanes between the tubular portion 47 and the skirt 68 without affecting the operation of this high suction termination. Such a condition is illustrated in Figure 9.

While small openings are desired for high suction generation, it is disadvantageous to have them too small, since they easily become closed off by dirt, dust and other foreign matter. Also in the winter they may be closed off by a film of water or ice, or by windblown snow. Also, too small openings create too great a throttling action to the flow through the openings. For these reasons I prefer to make the perforations square or circular with minimum dimension from 0.2 to 1.0 inch.

I have explained above how the leading edge of a cylindrical obstacle placed in the path of a moving fluid will show a pressure-generation on the leading face. The circumferential angle through which this pressure effect is carried is of the order of 60 to 80 degrees. It carries the full axial length of the obstruction. I have also shown how the balance between suction and pressure can be altered by controlling the amount of suction generated, as by altering the circumferential contour of the termination. It will therefore be clear that it is possible to build up the resultant suction-generative effect by reducing the pressure-generative effect, as well as by increasing the suction-generative effect. One way of decreasing the pressure generative effect is to shorten the zone of pressure generation, by forming a spherical, or a spheroidal surface contour, rather than a cylindrical contour .

In Figure 10 I have illustrated one way of approaching this condition. As in Figure 9 it comprises a tubular element 47, an annular plate 48, a cap 46 and a perforated skirt 68. In this case the skirt and cap form a hemispherical-like shape. Only the lower portion of the skirt is cylindrical, and only that part of the surface will be pressure generative when exposed to the transverse flow of fluid. This is indicated by flow line 71 in the moving fluid, which is essentially perpendicular to the skirt surface. Flow lines 72 and 73 are diverted upwards and flow along the surface causing generation of suction. As in the case of Figures 5 and 9, a cylindrical element 70 cooperates with cap 46 to provide a rain shield over the end of the tubular element 47. It is clear also that the tubular element 47 can be the conduit itself, or an extension of the conduit.

The embodiment shown in Figure 11 illustrate the design of another type of high suction termination. It consists of an essentially spherical or spheroidal portion 79 with perforations 69, which corresponds to the skirt 68 of Figure 10. A rain shield 74 protects the end of the conduit 31 or conduit extension 76. The tubular section 76 carries an outer cylindrical portion 80 which cooperates with the end of the conduit 31. Also carried by 76 are brackets 77 which support the shield 74. The perforated surface portion may, if desired, be made in two parts 79 and 75, joined together along a seam 78. Fastening of the two portions is facilitated by means of the strap 81 which covers the seam 78. The lower portion 75 may be attached to the tubular section 76 by welding or other conventional means.

The spherical shape of the surface 79—75 creates a streamlined flow of air over the surface no matter what the direction or attitude of the wind. Furthermore, due to the spherical shape, a minimum area of the surface is pressure-generative. Consequently this type of structure provides a high suction-generative capacity.

I have mentioned above how it is possible in the case of the embodiment of Figure 3 to adjust the suction- and pressure-generative action of the termination by adjustment of the vertical position of this termination in the end of the conduit. Also, in the case of Figure 5, I have shown how the same effect can be obtained by adjustment of the number of vanes and the depth of the channels therebetween. It will be obvious that the principles of the embodiment of Figure 5 can be applied to the structure of Figure 3. Thus, by proper shaping of the core 28 and by proper choice of the number and spacing of the vanes of Figure 3 the action of the termination can be altered independently of its position in the conduit.

It will be clear also that for each of the two principal embodiments shown in Figures 3 and 5 there is an adjustment of the termination for which the termination produces substantially no pressure or suction. An example of the use of such a neutral action is illustrated in Figure 12. This is a case where the inlet and exhaust pipes from a combustion chamber for example, are both exposed to the atmosphere. They are both brought into a cylindrical chamber formed by tube 90, having bottom 91. The exhaust pipe 82 is brought up through the bottom plate 91. The inlet pipe is shown as leaving the chamber at the side as pipe 84. The top of the chamber 90 is fitted with a termination 88 resting on cross brace 89. Termination 88 may be similar to those shown in Figure 1. The paths of the exhaust gases through the termination openings are shown schematically as 83 and 87. Both of the two openings leading from the combustion chamber are exposed to the same pressure, namely the pressure in the chamber 90. There are thus no unbalanced pneumatic pressures across

the combustion chamber, except the thermal convection pressures generated by the heat of the combustion. Since the adjustment of termination 88 is substantially neutral there is no effect of the wind on the pressure in the chamber 90 and therefore no effect of the wind on the combustion chamber. The termination 88 need not be neutral in adjustment and effect, but may be pressure- or suction-generative without affecting the operation of this assembly.

In this embodiment, the inlet and outlet pipes are subjected to the same pressures, and thus no flow of fluid through the chamber can be set up by the wind blowing on the termination. The same effect can be obtained by placing identically operating terminations on the two pipes 11 and 12 of Figure 1. In this case only the convection pressures are effective in circulating air through the chamber, since if the terminations are identical, and are placed in such positions that they are subject to substantially the same flow of air, the pressures generated at each termination will be the same and will be balanced. This arrangement is satisfactory for many cases, but where a positive flow of air through the system is required I choose to create a positive pressure across the chamber and so prefer the arrangement shown in Figure 1, providing a pressure-generative termination on one opening and a suction-generative termination on the other.

While I have described my invention in terms of the foregoing specific embodiments and modifications, it is obvious that many further embodiments and modifications are possible and will occur to those skilled in the art. For example the termination unit need not be a separate fixture inserted into, supported by or otherwise attached to a conduit, but can be a part of the conduit itself. Furthermore it is possible, by following the teachings of my invention, to construct a combination termination unit comprising a pressure generative and a suction generative portion, both of which are exposed to substantially the same fluid flow conditions. The invention therefore should not be considered as limited to systems with the exact details described, but is rather to be ascertained from the scope of the appended claim.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

In a fluid carrying conduit one end of which is exposed to the flow of a mass of fluid, the improvement which comprises a vaned assembly across the flow area of said conduit, including a tubular portion near its first end, an annular disc surrounding said tubular portion, a multiplicity of substantially similar longitudinal vanes projecting outwardly in a symmetrical pattern from the surface of said tubular portion and abutting said annular disc, the second end of said vaned assembly being inserted for a portion of the length of said vanes into a cylindrical cup of substantially the same diameter as said vaned assembly, said cup being spaced from the end of said tubular portion so as to permit free flow of fluid over the end of said tubular portion, the sole means of communication between said conduit and said mass of fluid being through the longitudinal channels formed by said tubular portion, said vanes and said cup, thence through said tubular portion and thence to said conduit, the openings formed by said vanes, said disc and said cup having longitudinal and transverse dimensions approximately equal, whereby, irrespective of the direction of flow of said fluid over said openings, the dimension of each opening in-line with said flow will be approximately the same, whereby the suction- or pressure-generative action due to said flow of fluid over said openings will be approximately the same.

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