A. R. KLEIN.

VENTILATING APPARATUS.

APPLICATION FILED MAR. 21, 1917.

1,303,210.

Patented May 6, 1919.

2 SHEETS—SHEET 1.

Fig. 1.

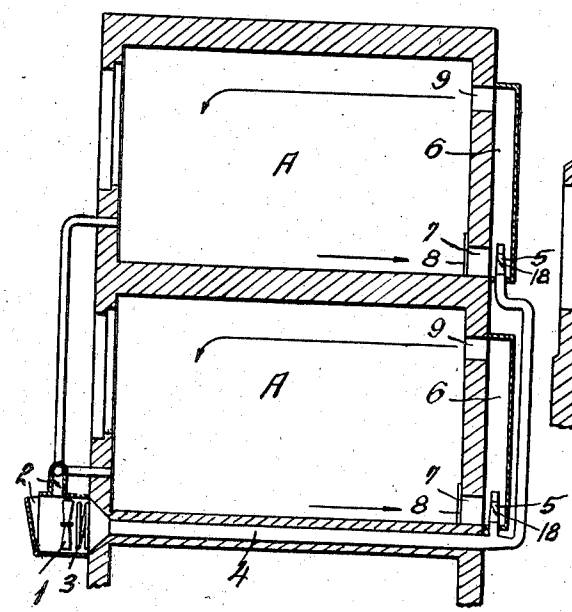


Fig. 2.

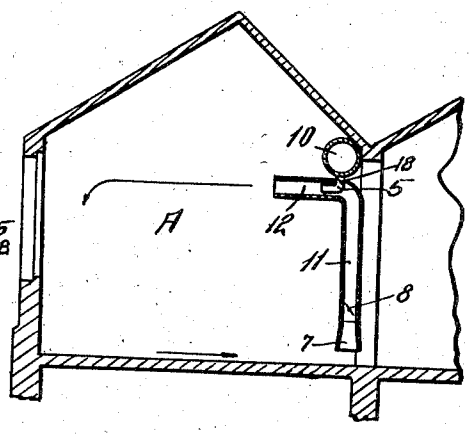
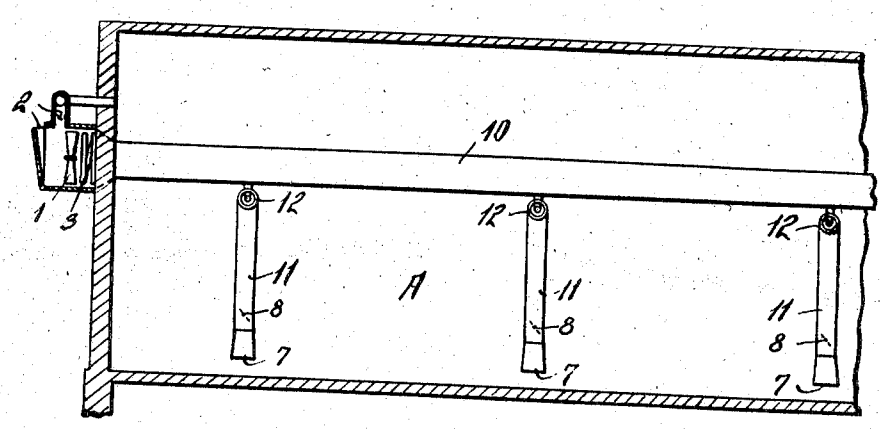


Fig. 3.



Albert R. Klein Inventor

By his Attorneys

Dennie Davis Morsell & Edmonds

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2 SHEETS—SHEET 2.

Fig. 4.

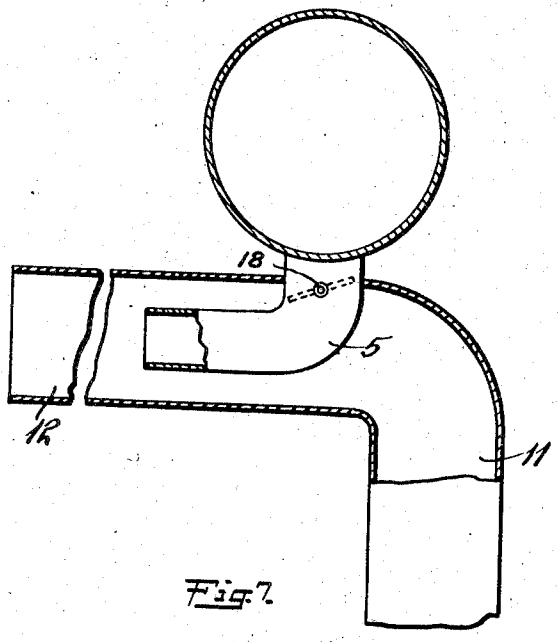


Fig. 5.

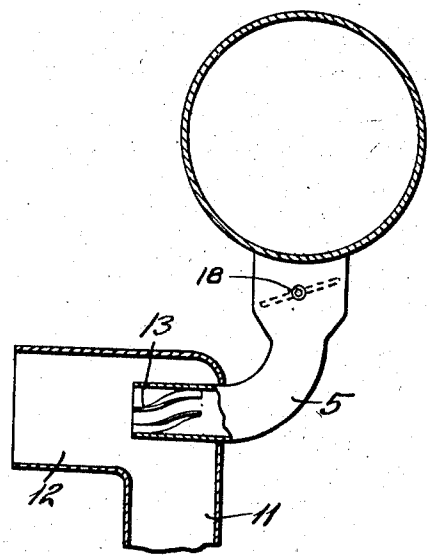


Fig. 7.

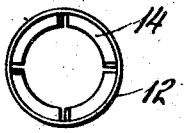


Fig. 6.

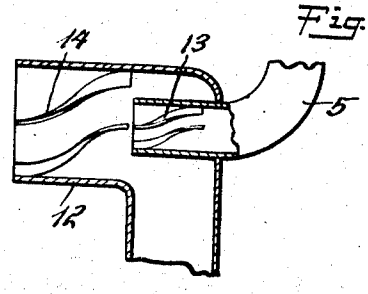


Fig. 8.

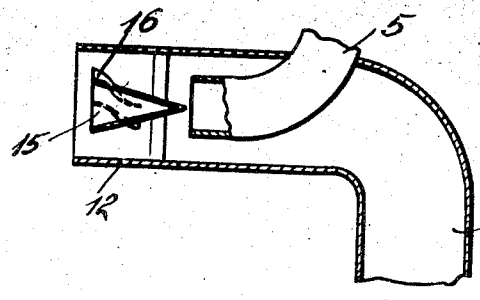
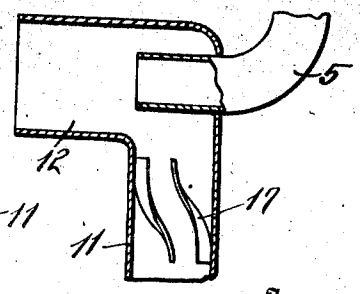


Fig. 9.



Albert R. Klein Inventor

By his Attorneys

Louis Stein Marin & Edmunds

UNITED STATES PATENT OFFICE.

ALBERT R. KLEIN, OF SPRINGFIELD, MASSACHUSETTS.

VENTILATING APPARATUS.

1,303,210. Specification of Letters Patent. Patented May 6, 1919.

Application filed March 21, 1917. Serial No. 156,426.

To all whom it may concern:

Be it known that I, ALBERT R. KLEIN, a subject of the Emperor of Germany, residing at Springfield, in the county of Hampden, State of Massachusetts, have invented certain new and useful Improvements in Ventilating Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In prior ventilating systems, fresh air consisting of exterior air, or interior air, or a mixture of both, is discharged into the interior to be ventilated, and in order that it may pass into the zone of occupancy of the interior, the fresh air is discharged from above, usually at high velocity and in a downwardly direction, or else the fresh air is allowed to escape into the interior through inlets located near the floor level. In the first case, the blasts may be uncomfortable to the occupants, especially where the air is heated or cooled, unless the air is discharged at too great an elevation to effectively reach the zone of occupancy; and in the second case the velocity of discharge is so low as to necessitate unduly large distributing conduits. In both cases, the total quantity of air discharged into the interior passes through the fan and distributing conduit, which, therefore, must be of comparatively large size and necessitate the use of a correspondingly large driving motor; and the air must also pass through the heating and conditioning apparatus, where employed, so that those parts of the system also must be of comparatively large size. In still other systems, the fresh air is discharged near the ceiling of the interior, and is drawn through the zone of occupancy by return conduits opening into the interior near the floor thereof, in which case however, in addition to the comparatively large distributing conduit and fan, a comparatively large return conduit, from the interior to the fan, is required.

In accordance with the present invention, effective circulation through the zone of occupancy is obtained without, however, employing return conduits, and without circulating the total quantity of air discharged into the interior to be ventilated through the distributing conduit or through the fan and conditioning apparatus, where employed. I do this by causing the fresh air to induce into mixture with it, just prior to entry into the interior, a comparatively large volume of air from the interior. For this purpose an inlet duct for the interior communicates with the distributing conduit, and a suction duct communicates at one end with the interior to be ventilated and at the other end with the inlet duct. By arranging the inlet to the interior above the zone of occupancy thereof, and the open end of the suction duct within that zone, or vice versa, the fresh air is effectively drawn through the zone of occupancy without discharging the mixture in strong blasts directed toward the zone of occupancy, and without the use of return conduits. Furthermore, since a comparatively large volume of air from the interior, say from one-half to nine-tenths or even more, is mixed with the fresh air just prior to entry into the interior, the distributing conduit conducts only a part of the air discharged into the interior and therefore may be of comparatively small size, or else the frequency of renewal of the air in the zone of occupancy is increased. In fact, these advantages may be combined, as desired. In this system it is preferable, though not essential, to provide a fan or other circulating means for maintaining a current of fresh air in the distributing conduit, but where used, the fan, and consequently the driving motor therefor, may be of comparatively small size, and likewise the conditioning apparatus, where used, may be of comparatively small size. Moreover, as a result of the fact that a comparatively large part of the mixture is air from the interior, the fresh air may be heated or cooled to a temperature considerably different from the temperature of the interior, and thus the heating or cooling apparatus may not only be decreased in size on account of the comparatively small quantity of air passed therethrough, but its operation is improved on account of the greater range of temperature employed.

Although it is not essential, I prefer to provide an injector in the inlet duct, because by so doing the velocity, or the pressure, or both, of the fresh air maintained in the distributing conduit may be increased without causing discomforting blasts in the zone of occupancy. Besides increasing the proportion of air from the interior induced into

mixture with the fresh air, by means of the injector, the size of the distributing conduit is further reduced. In fact, I even prefer to increase the induction effect of the injector. I find that this may be done by increasing the length of the inlet duct but, preferably by providing means for causing the air to whirl in passing through that duct. This whirling effect may be accomplished by causing the fresh air, or a portion of it, to take a spiral path along the injector, or along the inlet duct as, for instance, by providing inwardly-projecting spirally-extending fins on the interior of the injector or the inlet duct, or both. If desired, the air may be caused to whirl in passing through the inlet duct by providing a spiral path in the suction duct for the air induced from the interior. The whirling motion of the air not only draws a larger proportion of air from the interior, even where the inlet duct is decreased in length, but it also serves to promote the mixing of the fresh air with the air from the interior before entry into the interior. Furthermore, the increased induction effect causes the air from the interior to flow into mixture with the fresh air at a higher velocity and therefore permits the use of suction ducts of smaller diameter.

In ventilating large interiors, such as large offices, hospitals, schools, auditoriums, mills, workshops, etc., I prefer to provide a number of inlets to the interior from the distributing conduit, and where necessary to provide a number of distributing conduits, thereby rendering more uniform the circulation and renewal of the air throughout the entire zone of occupancy of the interior. Whether one or a number of inlets are provided, the circulation and frequency of renewal within the zone of occupancy may be effectively varied by dampers regulating the flow of interior air through the suction ducts, and this variation may be further modified in a desirable manner by also providing dampers for regulating the quantity of fresh air passing from the distributing conduit into the inlet ducts. In practice, I find that a desirable form of the inlet duct and the suction duct consists of a pipe hung within the interior to be ventilated and having a substantially horizontal portion which is located above the zone of occupancy and into which the injector extends, and also having a substantially vertical portion extending in close proximity to the floor.

Systems in accordance with this invention may embody all or only some of the foregoing instrumentalities, and the apparatus may, if desired, be operated in substantial accordance with the process disclosed in my copending application Serial No. 43,197, filed August 2, 1915.

In the accompanying drawings, illustrating the preferred embodiments of the invention, wherein, as an example, a fan, together with heating or cooling apparatus, and conditioning apparatus, are employed.

Figure 1 represents a transverse section of a building, having wall and floor conduits for distributing fresh air to a number of interiors; Fig. 2 represents in transverse section, and Fig. 3 in longitudinal section, an industrial shop provided with a hanging flue for distributing the fresh air; Fig. 4 represents, on a larger scale, partly in elevation and partly in section, one of the injectors connected to a distributing flue, and the pipe for conducting the air from the interior into mixture with the fresh air, and for discharging the mixture into the interior; Fig. 5 represents in like view such a pipe with, however, a shorter inlet duct, and an injector provided with spiraled fins for causing the fresh air to whirl; Fig. 6 represents an arrangement similar to Fig. 5, excepting that spiral fins are also arranged on the inside of the inlet pipe; Fig. 7 is a front view of the inlet pipe of Fig. 6; Fig. 8 shows a conical member having spiral fins on its exterior; and Fig. 9 shows an arrangement in which spiral fins are in the suction duct.

In the wall and floor conduit system of Fig. 1, fresh air is drawn by the fan 1 from the exterior, or from the interior, or from both places, in amounts regulated by the valves or dampers 2, and is forced through a water spray or other cleansing or humidifying apparatus into contact with the heating or cooling apparatus, all of which apparatus is indicated by the reference 3. The fresh air then passes through the floor conduit 4 and through each of the injectors 5, or other devices suitable for inducing currents of air into the wall conduits 6 through outlets 7 controlled by regulating valves or dampers 8. The fresh air and air drawn from the lower zone of the interiors through the outlets 7 mix at the end of the injectors 5 just prior to entry of the mixtures into the upper zone of the interiors at the inlets 9.

In the flue system of Figs. 2 and 3, the fresh air is forced through the distributing conduit or flue 10. In case of a large interior, as shown, the current of fresh air is sub-divided at a suitable number of places along the length of the conduit, and each sub-divided current is directed through an injector 5, thereby inducing separate currents of air through the vertical suction ducts 11 which extend from the lower zone of the interior to the places of mixture with the fresh air just prior to entry of the mixtures into the interior. The mixtures are then discharged into the upper zone of the interior A at separated places, through the inlet ducts 12.

In both systems hereinbefore described, the air from the lower zone of the interior preferably enters the outlets at 7 at four feet

or less above the floor level, although the outlets may, if desired, be located eight feet above the floor level; and the mixtures are preferably directed into the upper zone of the interior above the heads of the occupants, that is, six to eighteen feet above the floor level, depending upon the purpose of the interior and the number of inlets, and also upon other conditions well known in the art. The air drawn through the outlets from the lower zone of the interior, aids materially in producing the downward movement of the mixtures from the inlets, thereby reducing the velocity of entry necessary for the air, when heated, to overcome its natural tendency to rise to the ceiling; and it also effects more uniformly distributed ventilation and heating or cooling of the air throughout the zone of occupancy, substantially from top to bottom thereof.

By means of the valves or dampers 2 and 8, and also the damper 18 in the injector connection, the temperature, velocity, humidity and other characteristics of the mixtures directed into the interior may be nicely varied in the systems of Figs. 1 and 2, and the frequency of renewal of air in the zone of occupancy may be varied by changing the proportion of the fresh air and the air induced from the interior through the outlets. Ordinarily, one-half to nine-tenths or even more of the mixture will be induced from the lower zone of the interior, while the proportional amounts taken from the exterior and interior to make up the fresh air will depend upon the exterior temperature and other well known conditions.

As a result of the fact that a comparatively large volume of air from the interior is mixed with the fresh air just prior to entry into the interior, the temperature of the fresh air may be considerably different from the temperature of the mixture discharged into the interior, and the velocity or pressure, or both, may be considerably higher than that of the mixture. In fact, in heating interiors in accordance with the present invention, the temperature of the fresh air may considerably exceed 120° F., which was formerly considered as the upper limit of temperature permissible in air blast systems; likewise the limit of 300 feet per minute as the velocity of the fresh air in the distributing conduits of prior air blast systems may be considerably exceeded on account of a reduction of velocity occurring just prior to entry into the interior, and also because drawing the air through the outlets permits the mixture to be discharged horizontally into the interior. The temperature to which the fresh air is cooled, when the system is used for cooling interiors, may be as low as 40° F., and the temperature to which the fresh air is heated, when the system is used for heating interiors, may be as high as 1,000° F., on account of the mixture of the heated or cooled air with a comparatively large volume of air from the interior just prior to entry into the interior, as aforesaid. Also, the pressure given to the air may be one-fiftieth of an ounce to four ounces, and the velocity may be 100 feet per minute to 10,000 feet per minute, depending upon the conditions obtaining in the system. These characteristic differences give means for considerably cheapening the entire circulating, conditioning and distributing apparatus, and also for reducing the cost of operation. The air in the zone of occupancy may be changed more frequently than heretofore even where return conduits were used, because the air is drawn from the interior through a comparatively short suction duct extending substantially to the place of discharge into the interior, instead of extending from the interior to the source of the system as heretofore.

In most cases the air from the interior will be drawn from a lower zone, and the mixture will be discharged into an upper zone, because this produces a more effective circulation in the interior. However, in some cases, such as theaters, it may be preferable to draw the air from an upper zone and discharge the mixture into a lower zone.

It is apparent that the invention herein disclosed does not necessarily require the use of a circulating fan, or conditioning apparatus, or an injector. In fact, the circulation may result from the natural tendency of heated air to rise in the distributing conduits, and the inducing effect of such currents of air may, in some cases, be sufficient to draw air from the interior into mixture with it, without employing an injector for the purpose. However, it is advisable in most cases to employ the injector to increase the inducing effect, and likewise the advantages of the system are usually realized in fullest measure by employing a fan to circulate the air at suitable velocity and pressure.

I have found that the inducing effect of the fresh air on the air drawn from the interior into mixture with it, is increased by increasing the length of the inlet duct 12. This increased inducing effect seems to result from increased friction of the air in passing along the inlet duct, but whether or not this explanation is the correct one, I have found by test on a certain system that the air induced from the interior by the fresh air is about 123% of the fresh air when the inlet duct extends three feet beyond the outer end of the injector, and about 181% of the fresh air when the inlet duct extends seven and one-half feet beyond, the injector employed and the other conditions obtaining in the system being otherwise the same. I have also found that

the induction may be increased by causing the air, or a portion thereof, to whirl in the inlet duct and, in fact, the increase is so material that a sufficiently large amount of air may be induced from the interior into mixture with the fresh air, when the inlet duct has a length of but three feet. Furthermore, when a suitable portion of the air is caused to whirl, the mixture of the air from the interior with the fresh air, is more thorough, so that air discharged into the interior is more homogeneous and more effective for ventilation, and heating or cooling.

In Figs. 2 and 4, I have shown comparatively long inlet ducts 12, such as would preferably be used where the fresh air is not given a whirling motion. In Figs. 5, 6, 7, 8 and 9, I show various means of causing the air to whirl in the inlet duct, and, if desired, this form of the apparatus may be substituted for the corresponding parts in Figs. 1 to 4. In Fig. 5, the interior of the injector is provided with spiraled fins 13, and in Figs. 6 and 7, spiraled fins 14 are also placed on the interior of the inlet duct to further increase the induction effect, the pitch of the spiral in both cases being approximately 200° per foot of duct. In Fig. 8, a conical member 15 has spiraled fins 16 on its exterior for causing a portion of the fresh air to whirl. With the construction shown in Fig. 5, and otherwise under the same conditions as in the tests hereinbefore mentioned, I find that the air induced from the interior by the fresh air is about 157% of the fresh air when the fins 13 are one-half inch high, and about 530% when the fins are two inches high, the inlet duct having a length of but three feet. As a result of the spiraled fins in the suction duct, as shown in Fig. 9, the air induced from the interior is caused to whirl in the suction duct. This produces a whirling motion of the air, or a portion of it, in the inlet duct, and thereby increases the induction effect on the air drawn from the interior.

By combining into a single pipe, the substantially horizontal inlet duct 12 and the substantially vertical suction duct 11, the most desirable construction is obtained in the flue system of Figs. 2 and 3.

Having thus described my invention, what I claim is:

1. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit communicating at one end with the interior to be supplied above such zone and at the other end with said interior substantially at the bottom of said zone; and means for discharging a current of fresh air into said conduit at a point between said ends, so as to draw air from said interior into and through the conduit to mix with and temper the fresh air passing therethrough, and to discharge the resultant mixture into said interior and cause its circulation through said zone.

2. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit embodying a horizontal inlet branch opening into the interior to be supplied above such zone and a vertical suction branch opening at its lower end into said zone; and a distributing conduit communicating with the inlet branch of the first-named conduit for discharging a current of fresh air therethrough, so as to draw air from said interior into and through the suction branch of said first-named conduit and into the said inlet branch to mix with and temper the fresh air passing through the latter branch, and to discharge the resultant mixture into said interior and cause its circulation through said zone.

3. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit communicating at one end with the interior to be supplied above such zone and at the other end with said interior substantially at the bottom of said zone; and means for discharging a current of fresh air into said conduit at a point between said ends, so as to draw air from said interior into and through the conduit to mix with and temper the fresh air passing therethrough, and to discharge the resultant mixture into said interior and cause its circulation through said zone; said air-discharging means including an injector having its outlet within said conduit.

4. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit communicating at one end with the interior to be supplied above such zone and at the other end with said interior substantially at the bottom of said zone; means for discharging a current of fresh air into said conduit at a point between said ends, so as to draw air from said interior into and through the conduit to mix with and temper the fresh air passing therethrough, and to discharge the resultant mixture into said interior and cause its circulation through said zone; said air-discharging means including an injector opening into said conduit; and means for increasing the induction of the injector.

5. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit embodying a horizontal inlet branch opening into the interior to be supplied above said zone and a vertical suction branch opening at its lower end into said zone; a distributing conduit com-

municating with the inlet branch of the first-named conduit for discharging a current of fresh air therethrough, so as to draw air from said interior into and through the suction branch of said first-named conduit and into the said inlet branch to mix with and temper the fresh air passing through the latter branch, and to discharge the resultant mixture into said interior and cause its circulation through said zone; and means for whirling the mixture passing through said inlet branch.

6. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit communicating at one end with the interior to be supplied above such zone and at the other end with said interior substantially at the bottom of said zone; and means for discharging a current of fresh air into said conduit at a point between said ends, so as to draw air from said interior into and through the conduit to mix with and temper the fresh air passing therethrough, and to discharge the resultant mixture into said interior and cause its circulation through said zone; said air-discharging means including an injector opening into said conduit and having a spiraled bore to whirl the air issuing therefrom.

7. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit communicating at one end with the interior to be supplied above such zone and at the other end with said interior substantially at the bottom of said zone; a distributing pipe in communication with said conduit for discharging a current of fresh air into the latter at a point between said ends, so as to draw air from said interior into and through the conduit to mix with and temper the fresh air passing therethrough, and to discharge the resultant mixture into said interior and cause its circulation through said zone; and means for increasing the induction of the air from the interior into the said conduit.

8. Apparatus for supplying air to interiors and for effecting circulation of such air through the zone of occupancy thereof, comprising a conduit embodying a horizontal inlet branch opening into the interior to be supplied above said zone and a vertical suction branch opening at its lower end into said zone; and a distributing conduit communicating with the inlet branch of the first-named conduit for discharging a current of fresh air therethrough, so as to draw air from said interior into and through the suction branch of said first-named conduit and into the said inlet branch to mix with and temper the fresh air passing through the latter branch, and to discharge the resultant mixture into said interior and cause its circulation through said zone; the said inlet branch having spiraled fins on its interior surface to whirl the air therein.

In testimony whereof I affix my signature.

ALBERT R. KLEIN.