Dec. 5, 1939. E. Q. COLE 2,182,690

AIR CONDITIONING APPARATUS

Filed May 15, 1937 2 Sheets-Sheet 1

Fig. 1

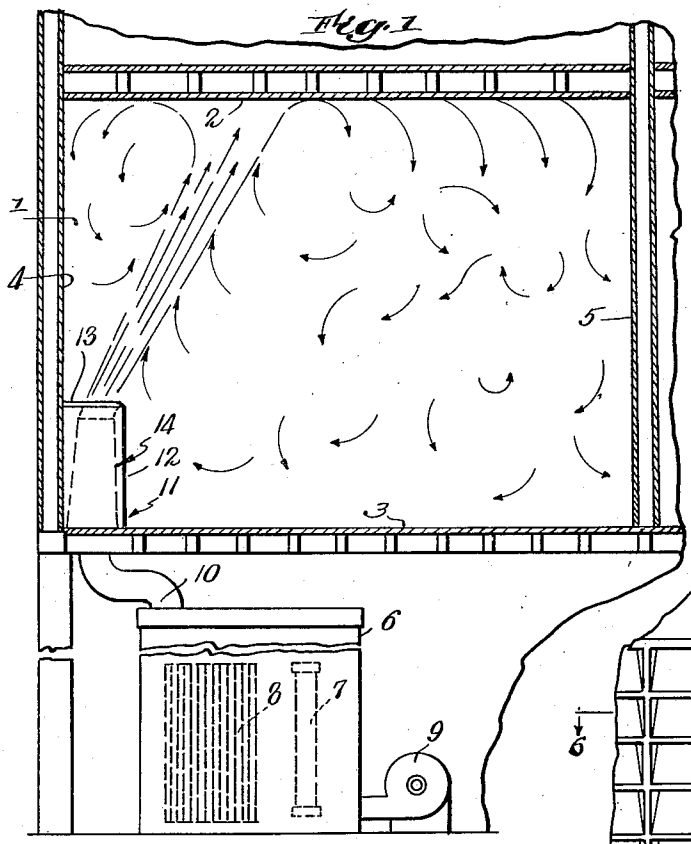


Fig. 7

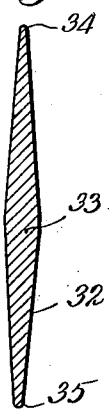


Fig. 4

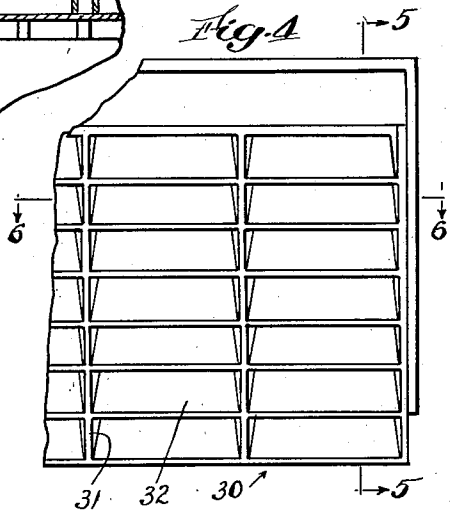


Fig. 2

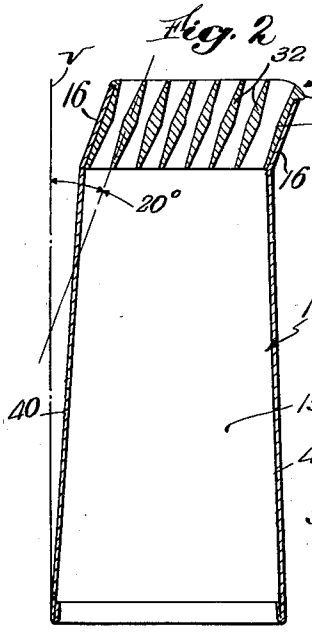


Fig. 6

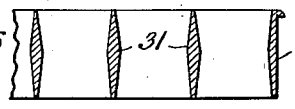


Fig. 3

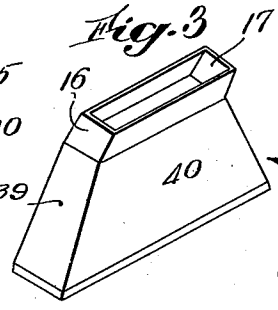
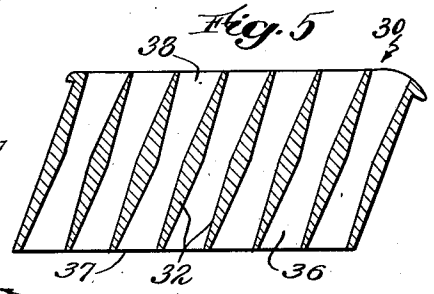


Fig. 5



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AIR CONDITIONING APPARATUS

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Fig. 8

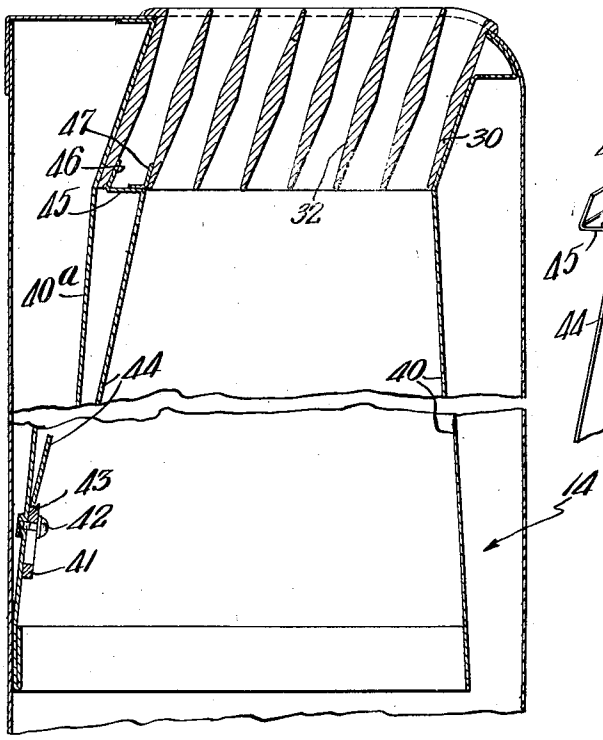


Fig. 10

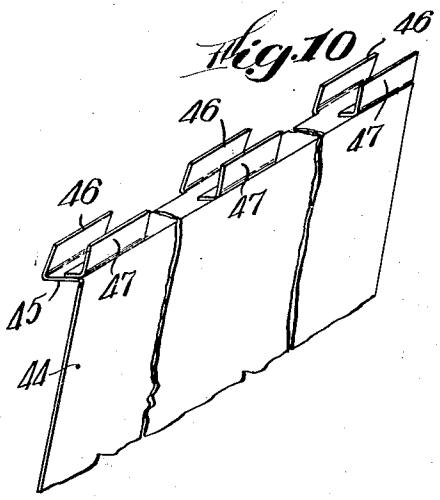


Fig. 11

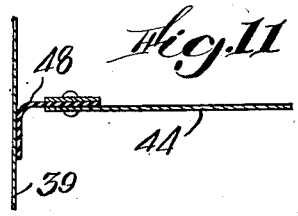
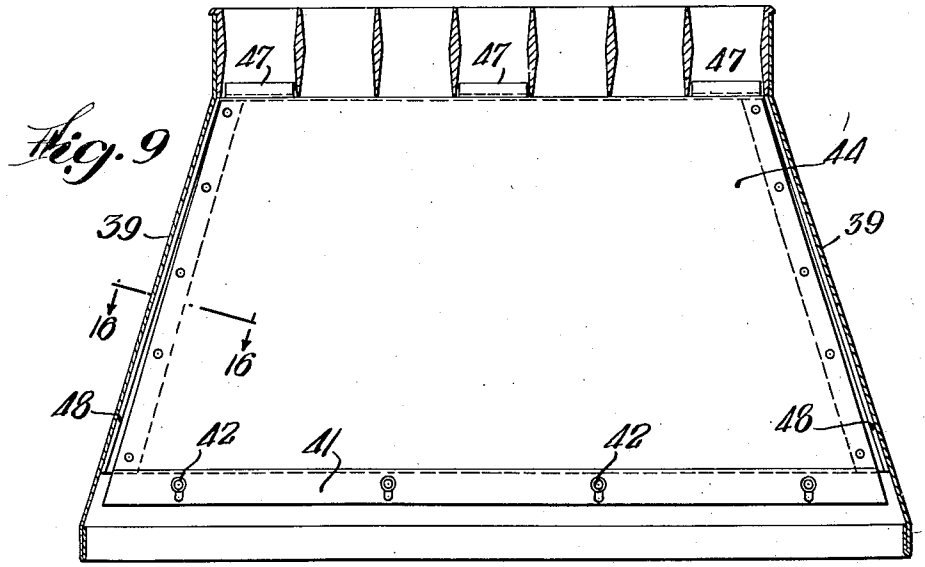


Fig. 9



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UNITED STATES PATENT OFFICE

2,182,690

AIR CONDITIONING APPARATUS

Edwin Q. Cole, Belmont, Mass.

Application May 15, 1937, Serial No. 142,789

5 Claims. (Cl. 98—39)

This invention pertains to an improved method of and apparatus for use in introducing gaseous fluid, for specific instance air, into a confined space such as the room of a dwelling. For illustration, but without intent to restrict the invention to such specific use, the invention is herein described with particular reference to its use in air conditioning, that is to say, the production of certain desirable conditions, for example, uniform temperature, moisture, or the like in the air of a habitable enclosed space.

The conditioning of such spaces as just referred to is commonly accomplished by the introduction of heated, cooled, or moistened air into the space, or by the use of radiating or absorbing surfaces or moistening devices, such as radiators or refrigerating coils or evaporating surfaces disposed within the space, but it is essential, for the production and maintenance of the desired conditions, and especially if any efficiency in operation is to be secured, that the air be kept in a constant state of turbulence throughout substantially the entire space in order to prevent stratification of the air and non-uniform conditions at different points. However, such motion of the air must not be in the form of appreciable currents, at least in the occupied portions of the space, since drafts whether warm or cold, cause discomfort and may constitute a distinct menace to the health of the occupants. The ideal condition is that in which the air is filled with gentle and substantially imperceptible eddies and swirls, but without definite currents in any particular direction, such ideal condition being hereinafter referred to as "turbulence".

For specific illustration of the utility of the invention, it will be assumed in the following discussion that the heating, cooling, or moistening effect is obtained solely by introducing a stream or current of air of predetermined character directly into the room. Whenever it has heretofore been attempted to temper the air in a room in the manner just referred to, great difficulty has been experienced in attaining the desired conditions, for unless the air be properly introduced the entering air does not establish any general turbulence. As a result, stratification takes place, the ceiling temperature being much higher than that at the floor, while areas adjacent to outside walls and windows are relatively cold as compared with parts not so exposed, and in the attempt to warm up the colder parts, other portions of the space must be overheated at the expense of excessive fuel consumption and loss of efficiency. On the other hand, in the effort to overcome such stratification, when the air is introduced at a velocity such as to cause it to sweep throughout the entire space, undesirable and prohibitively strong drafts have usually been set up.

A principal object of the invention is to provide a method of and means for so delivering air into a confined space as to establish the desired degree of turbulence without producing objectionable or appreciable drafts.

It has previously been proposed to introduce air currents of fairly high velocity in a generally upward direction so as to avoid horizontal currents or drafts, but unless a smooth compact stream be properly established, it quickly breaks up after leaving the delivery point and is thus ineffective for the desired purpose. It is, therefore, a further object of the invention to furnish a method of and means for creating and delivering a smooth compact fluid jet or stream, capable, when delivered into a body of similar fluid, of maintaining its integrity without substantially breaking or intermingling with the surrounding body of fluid, for a substantial distance from its point of delivery.

For aesthetic and architectural reasons it is sometimes undesirable to arrange the entrance orifice or grill through which the air stream enters the space at an angle to the horizontal. Unsuccessful attempts have previously been made to direct the air itself upwardly in an inclined path by delivering it through a horizontally disposed orifice or grill opening provided with inclined grid bars or louvres of the usual plane or slat-like type, but such an arrangement does not function as intended. No previous grill or grid, so far as is known to me, will effectively direct the outflowing stream unless the grill or grid as a whole is disposed at a very definite angle. Moreover, in the usual grid or grill the continuity of the entering current is broken by its impingement upon and change of direction by the grid bars so that as it enters the room it is full or swirls and eddies, causes an undesirable rushing noise, and quickly loses its velocity, direction and effectiveness.

A further object of the present invention is to provide novel air delivery means so designed that while the plane of the delivery grid may be at any desired angle with reference to the horizontal, the air current may be delivered in a smooth, noiseless and compact stream at high velocity at the same or some other chosen angle.

A further important factor in conditioning air is to maintain the temperature and/or moisture

condition of the space to be treated, at a constant predetermined point. Automatic devices controlling the temperature and humidity, are influenced by slight changes in the air immediately surrounding them. Previous attempts have been made to control the temperature, and/or the humidity of the entering air so as to hold the room air at a constant predetermined temperature and percentage of relative humidity, but the entering air ordinarily diffuses through the room so slowly that room air fluctuates up and down relatively to the point the control instruments are set for. It is, therefore, a further important object of the present invention to provide a novel air delivery means designed to diffuse the entering air throughout the room so rapidly and with such constant uniformity that only a matter of seconds shall elapse before air entering the room will affect the control instruments, whatever their location, causing them to bring the entering air to a temperature and/or humidity such as will hold the room air constant at the desired degree of heat and humidity, and thus effectively prevent the usual objectionable fluctuations, yet without appreciable drafts, it being noted that draft prevention is very important to human comfort, and also in many kinds of process work in manufacturing.

Previous attempts have been made to deliver air to rooms at temperatures at or below room temperature to prevent overheating or to cool the rooms to a lower temperature. Heretofore, this has been impossible without causing serious cold drafts and too rapid chilling in parts of the occupied zone. It is, therefore, a further important object of this invention to provide a novel air delivery means so designed that air at temperatures substantially below room temperature may be delivered to the room and diffused uniformly throughout the room air without causing appreciable drafts or chilling sensations.

Fig. 1 is a fragmentary diagrammatic vertical section, illustrative of one utility of the present invention, showing the improved air delivery means arranged to distribute conditioned air in an enclosed space or room;

Fig. 2 is a vertical section, to larger scale, showing a preferred form of grid and the pressure tube through which the air flows on its way to the grid;

Fig. 3 is a perspective view, to smaller scale, of the distributing nozzle and pressure tube, but omitting the delivery grill;

Fig. 4 is a fragmentary plan view of a device such as that of Fig. 2, to larger scale, and showing a preferred form of delivery grill;

Fig. 5 is a vertical section substantially on the line 5—5 of Fig. 4;

Fig. 6 is a fragmentary section on the line 6—6 of Fig. 4;

Fig. 7 is a vertical section to larger scale through one of the grid bars of the grill of Figs. 4 to 6 inclusive;

Fig. 8 is a view similar to Fig. 2, but illustrating a modified form of pressure tube;

Fig. 9 is a rear elevation of the parts shown in Fig. 8;

Fig. 10 is a fragmentary perspective view illustrating the upper edge of an air deflector element forming a part of the structure of Fig. 8; and

Fig. 11 is a fragmentary horizontal section of said deflector element illustrating the employment of packing means between such deflector element and the end wall of the tube.

Referring to the drawings, the numeral 1 designates a space, illustrative of any space in which air turbulence is to be established, with or without change in temperature, moisture or the like. For example, this space may be the room of a dwelling or apartment defined by an enclosure including a ceiling 2, a floor 3, and side walls 4, 5, etc. In some other space which may be remote from the space 1, for example, a basement or the like, there is arranged apparatus, including for example a fan, for creating an air current. This apparatus may also include air warming, cooling, drying or moistening means and is here shown as comprising a casing having therein air purifying and/or moistening or drying means 7 and temperature changing coils 8, the apparatus also comprising a fan 9 or equivalent means whereby air may be caused to enter the casing 6 and to flow outwardly under predetermined pressure through the outlet conduit or conduits 10. Since the present invention is not specifically concerned with the way in which the air is conditioned or the particular means employed for conditioning it, but only with the proper formation and delivery of the air into the space to be treated, it is unnecessary to describe the conditioning apparatus in greater detail.

As illustrated in Fig. 1, the conduit 10 leads to the air-distributing apparatus 11 located within the space 1. This distributing apparatus in the specific embodiment illustrated preferably comprises an outside casing 12 which may be of any desired material and preferably of ornamental appearance, such casing having the upper substantially horizontal surface 13, and being disposed closely adjacent to one side wall, for example, the wall 4, of the space 1. Within the casing 12 (which functionally is unnecessary to the practice of the present invention, although desirable for ornamental and aesthetic reasons) there is located the nozzle device comprising the pressure tube 14 and the grid 30. The lower end of the tube communicates with the conduit 10 and, although said lower end is of larger cross-sectional area than the conduit, yet the tube in effect forms a continuation of said conduit. This pressure tube 14 is so shaped as to provide an upwardly converging passage 15 leading to the grid-holding section 16. As the air flows along this converging passage its pressure is increased and substantially uniform flow conditions are established so that in entering the grid the air has substantially the same pressure and velocity at all points. As particularly illustrated in Fig. 3, the pressure tube 14 is conveniently of truncated pyramidal form, the grid-holding section 16 being secured to the upper, smaller end of the pressure tube. The grid-holding section is preferably of rectangular contour with its upper open end 17, as here illustrated, disposed in a substantially horizontal plane and within an appropriately shaped opening in the top wall 13 of the casing 12.

Within the upper end of the grid-holding section 16 there is disposed a delivery grid or grill 30 (Figs. 2, 4, 5 and 6) such grill being for example of cast iron or the like and preferably having a flange 30a which rests upon the upper edge of the grid-holding section 16 and which, if desired, may overlap the edges of the opening in the part 13. While it has just been suggested that this grill may be of cast iron it may manifestly be made of any other suitable material, for example other cast metals, moulded synthetic resin, cellulosic derivatives, wood, or of

sheet material suitably pressed or assembled to the desired shape.

The grill **30** comprises the transverse vertical bars **31** (Fig. 6) and the longitudinal inclined bars **32** (Fig. 5), the bars of both sets preferably being of substantially the vertical cross section indicated in Fig. 2, for example. Thus each of these bars has a thin or narrow upper edge **34** and a similar thin or narrow lower edge **35** (such edges being smoothly rounded) and a thicker central portion **33**, the thickest portion of each bar preferably being about midway between its upper and lower edges so that a very substantial portion of the passage acts to give definite direction to the flowing air and gradually to compress it, before it reaches the point of greatest compression, beyond which it begins to expand. With such an arrangement any given passage **36** (Fig. 5) between adjacent bars of the grid or grill is of convergent-divergent shape, that is to say, constitutes in effect a true Venturi orifice, and when, hereinafter a Venturi orifice or passage is referred to, it is intended thereby to indicate a convergent-divergent passage of which the length of the convergent portion is a substantial fraction of the entire length of the passage.

It has heretofore been proposed to employ an air distributing grid or grill comprising bars which are thinner at their delivery edges than at those edges which are first impinged by the air current, but experience has proven that such a grid or grill, if arranged in a horizontal outlet to an air discharge passage, is not effective to produce a compact smooth jet capable of maintaining its shape for any distance after leaving the nozzle nor of imposing upon the delivered stream an angle substantially different from that of the approaching air stream, even though the bars of the grid be inclined so as to slope in the desired direction of the delivered stream. This failure to function appears to be due to the fact that no definite directional movement has been imposed upon the air stream before it reaches the point of maximum compression, and that eddies have not been eliminated before the air reaches that point.

Under some conditions, for example, by reason of space limitations, it is necessary to be able to deliver the air from the nozzle in a direction quite different from its direction of approach to the grid, and for the purpose of the present invention, to impart to such delivered stream the capability of maintaining its emergent direction and high velocity for a considerable distance after leaving the nozzle. As shown, the inner surface of the pressure tube **14** is smooth and devoid of projections or irregularities which might cause eddies in the air current, and is designed to conduct the air in a smooth undeflected stream with increasing pressure to the point where the stream is divided by the smooth lower edges of the grid bars. As is well known, an orifice of this shape tends to create a smooth substantially perfect flow of fluid entering at one end and emerging from the other end of the orifice. While it has long been known that a single orifice of the Venturi type tends to produce a smooth compact emergent fluid stream, it appears, as the result of extended experiment, that even better results are obtained by grouping orifices of Venturi type so that the several jets of flowing fluid which emerge from the grouped orifices are so closely associated that each jet tends to smooth and "iron out" the jet next adjacent to it. Such a grouping of orifices of the Venturi type results from the use of a grid structure like that here disclosed. Each individual orifice produces a jet or filament of smooth compact form having the inherent tendency to expand transversely as it leaves the orifice, but apparently being prevented from freely expanding by contact with the next adjacent jet or filament which has the same tendency, the net result being that the composite stream maintains its integrity, flowing straight and smooth without eddies or tendency to break up or merge with the ambient air until it has traveled a very substantial distance from the delivery point. Whatever the actual cause, the effects are those just described, for by the use of such delivery device or its equivalent, the emergent air stream may readily be delivered in a definite predetermined direction, substantially without noise, and so as to maintain its integrity substantially unbroken until it impinges against a wall or ceiling surface much further from the delivery point than has heretofore been possible. By the use of the grid **30** the direction of the delivered air stream is definitely determined and fixed by and substantially corresponds with the direction of the axes of the passages **36** of the grid regardless of the direction of approach of the air toward the grid. Thus the outlet grid or grill may be disposed in substantially any desired position, from horizontal to vertical, regardless of the direction of the current in the pressure tube **14**. In this connection it is to be noted that it is the inclination of the grid bars and not the position of the grid as a whole which determines the direction of the effluent air stream. With the improved nozzle device herein described, it is readily possible, for example, to deliver a stream of warm air into a body of cooler air at a relatively small angle to the horizontal, and cause such stream to travel in a substantially straight path for a very considerable distance, without bending upwardly due to its lesser specific gravity than the surrounding air, or vice versa, to deliver air cooler than the room air upwardly at an angle for impingement against the ceiling but without having it curved downwardly due to its greater weight.

For such use as that above specified, to wit, the creation of turbulence in room air, it has been found that the angle of delivery of the air stream and the velocity of the emergent air should vary to some extent in accordance with the dimensions of the room. As specific examples, merely by way of illustration, for comparatively small rooms, for instance a room eight by ten feet, having a ceiling height of from eight to ten feet, the stream should enter at a point adjacent to one of the walls of the room and move upwardly at an angle of the order of 20° of divergence from said wall and with a delivery velocity of the order of 500 feet per minute. On the other hand, for a large room, for instance, a room twenty feet by thirty feet with a ceiling height of the order of sixteen feet, the air should enter at a slightly less angle of divergence from the side wall, for example, 15° and with a velocity of the order of 1500 feet per minute. For best results, the stream should enter at a point substantially midway the length of the adjacent wall, but it is apparently unimportant whether it be delivered adjacent to the longer or shorter wall if the room is not square.

While it is desirable, in order to avoid contact of the emergent stream with the occupants of

the room, to deliver it some distance from the floor, for instance at a height of thirty inches from the floor, it may, if desired, be delivered from a point nearer the floor, if circumstances will permit. As a matter of fact, the nearer to the floor that the point of discharge can be conveniently arranged, the better the results may be expected to be.

While, as here illustrated, the improved delivery grid is shown as arranged to direct its stream toward and against the ceiling of the space, in order to effect the desired turbulence, it is to be understood that the improved delivery grid is of broader utility and applicable wherever it is useful to have an entering stream of fluid maintain its integrity for a substantial distance from the nozzle while flowing through an ambient body of relatively still fluid, and whether or not the stream eventually impinges upon a solid deflecting or abutment surface such as a wall or ceiling.

As above pointed out, the pressure tube **14** is conveniently of truncated pyramidal shape, and this tube may be made from sheet metal or any other suitable material. As shown in Fig. 3 the tube comprises the sloping end walls **39** and the sloping front and rear walls **40**. In its simplest embodiment this tube **14** may provide a convergent air passage **15** (Fig. 2) of fixed dimensions. However, it is an essential characteristic of the present invention that the air velocity in leaving the nozzle shall be relatively high. In order to permit the use of grills and pressure tubes of more or less standard dimensions, but useful for distributing air into spaces of different cubic capacity or different shape, it is preferred to employ a pressure tube such as that illustrated, for example, in Figs. 8 to 11, inclusive. Thus in Fig. 8 the pressure tube is shown as comprising the sloping front and rear walls **40** and **40a**, providing a tube of fixed dimensions like that of Fig. 2, but in this instance the rear wall **40a** is provided adjacent to its lower edge with a vertically adjustable supporting member **41** secured to the wall **40a**, for example, by means of bolts **42** working in slots in the member **41**. The upper edge of this horizontally extending supporting member **41** is preferably beveled as at **43**, thereby to provide a pocket or channel between its outer face and the inner surface of the wall member **40a**. This channel is designed to receive the lower edge of an adjustable deflector plate **44**. This plate extends up to the under side of the grid **30** and is preferably furnished with a substantially horizontal flange **45** (Fig. 10) designed to abut the lower edges of the grid bars **32**. The free edge of this flange **45** is turned upwardly, as shown at **46**, to provide a positioning member designed to engage the inner surface of one of the grid bars—the member **46** preferably being inclined substantially to the same angle as the lower part of the grid bar. A second positioning member **47** is secured to the flange **45** in such a position as to engage the inner surface of the next adjacent grid bar **32**. These members **46** and **47** may be somewhat resilient so as to permit them to be sprung up between the grid bars and to make tight contact with the grid bars at whatever angle the plate **44** may be disposed. As illustrated in Fig. 8, the plate **44** is so disposed as to cut off the entrance to the passage between the left-hand pair of grid bars, thus decreasing the effective width of the grid and so confining the air current which is delivered through the pressure tube to the spaces between the remaining or active bars. Thus although the volume of air discharged by the nozzle may be less than that which normally would be furnished to a grid of the same size, the velocity of such air may be kept up to the standard by reason of the lesser discharge area through the pressure tube.

If the deflector plate **44** were to be moved to a new position, to the right of that illustrated in Fig. 8, its flange **45** would then uncover the space between the left-hand pair of grid bars, and any air leaking between the lateral edges of the plate and the end walls of the pressure tube might thus escape into the room and interfere with the designed operation of the apparatus.

In order to avoid such leakage of air past the lateral edges of the deflector plate **44**, the latter, as illustrated in Fig. 11, may be provided with a flexible packing strip **48** which bears against the end wall **39** of the pressure tube and thus prevents air from the tube from escaping into the space behind the deflector plate.

In operation, the conditioned air from the conditioning apparatus **6** is delivered through the conduit **10** to the nozzle device and escapes upwardly into the room at an angle to the vertical which is determined solely by the inclination of the bars of the grill or grid device. For producing turbulence in room air while avoiding impingement of sensible air currents upon the occupants of the space, it is desirable to arrange the top wall **13** of the case **12** from twenty-four to thirty inches above the floor **3** and it is also desirable to place the delivery grid as close as practicable to a side wall of the space. As the air from the conduit **10** enters the convergent passage **15** (Fig. 2) its pressure is gradually built up and substantial uniformity of velocity is established across the entire transverse area of the stream so that the velocity of discharge from the several orifices is substantially equal and a smooth compact stream is created such as is essential to carry the emerging air in a substantially unbroken and noiseless stream upwardly until it strikes the ceiling of the room. This high velocity stream of air tends to entrain with it a large volume of room air, but when delivered from the nozzle device at a proper velocity it does not substantially change its direction or break up until it impinges upon the ceiling. It then very quickly mushrooms and spreads over the entire area of the ceiling, and then, moving downwardly, it forms innumerable eddies and swirls, creating substantially uniform turbulence throughout the entire space, although without causing appreciable noise, drafts or noticeable air currents such as would cause discomfort or injure the occupants of the room.

While, as a specific instance of the utility and mode of application of the invention, it has hereinabove been described with reference to the creation of proper atmospheric conditions in a dwelling room, it is contemplated that it is of broader value, for example for creating desirable atmospheric conditions in manufacturing establishments, or in enclosures wherein processes, demanding particular and definite air conditions, are used and that when so applied, the invention may be embodied in apparatus widely different in appearance from that above described and arranged to introduce air in any desired direction, even including its discharge downwardly so as to impinge upon the floor. Accordingly I wish it to be understood that the invention is not necessarily limited to the precise construction

shown, nor to the specific dimensions suggested by way of example, but that the invention is doubtless capable of embodiment in and by means of other apparatus of equivalent type and is to be regarded as of broad scope and utility as defined by the appended claims.

I claim:

1. Apparatus for use in creating air turbulence in a confined space having a ceiling and walls, said apparatus comprising means for creating an air current, a smoothly converging conduit for leading the air current to the vicinity of said space, and air discharge means located within the space, said discharge means defining a group of closely adjacent Venturi-type orifices directed upwardly toward the ceiling with their axes substantially parallel and arranged collectively to deliver the air in a plurality of contacting jets, each tending to expand laterally whereby the emergent stream tends to follow a substantially straight path for a considerable distance from the point of discharge, the current-creating means being operative to deliver a stream having a discharge velocity sufficient to cause it forcibly to impinge upon the ceiling.

2. Apparatus for use in creating air turbulence in a confined space having a ceiling and walls, said apparatus comprising an air supply conduit, air discharge means located within the space and arranged to receive air from the conduit, said air discharge means comprising a nozzle including a grid device disposed in a substantially horizontal plane, said grid device being constructed and arranged to define a group of closely adjacent Venturi-type orifices having their axes substantially parallel and inclined to the vertical, means within the conduit providing a smoothly convergent passage leading toward the nozzle, and means for forcing air through the conduit under such pressure that it discharges from the nozzle at high velocity.

3. Apparatus for use in producing air turbulence within a space defined by a floor, ceiling and walls, said apparatus comprising an air supply conduit, air discharge means located within the space and arranged to receive air from the conduit, said air discharge means comprising a nozzle arranged to deliver air upwardly from a point spaced a distance of the order of 30 inches above the floor, said nozzle having therein horizontal grid means comprising bars which define a plurality of closely adjacent, substantially parallel orifices each of Venturi-type and having their axes diverging upwardly from the adjacent wall, and means for creating a current of air for discharge through said nozzle at a velocity such that it flows upwardly in a smooth stream and impinges against the ceiling before breaking or substantially changing its direction.

4. A discharge nozzle for use in apparatus of the class described comprising a casing having in one wall thereof a delivery opening and a substantially horizontal grid extending across said opening, said grid having bars which define a plurality of Venturi-type passages whose axes are substantially parallel and inclined to the vertical and through which the air moves, said passages being constructed and arranged to deliver the air in smooth flowing streams, each tending to expand laterally and which fuse and collectively constitute a solid column, more dense than the surrounding air, which, after leaving the nozzle, follows a path in which the constituent streams remain substantially coaxial with the respective passages from which they emerged, regardless of the plane of the delivery opening.

5. A discharge nozzle for use in creating a smooth shape-retaining substantially noiseless high velicity air stream, said nozzle comprising a casing of truncated pyramidal contour having convergent walls and an end portion of substantially rectangular cross section inclined to the main body portion of the casing, said inclined end portion terminating in a substantially horizontal plane, and a substantially horizontal air-directing grid within said inclined portion of the casing, said grid comprising bars so shaped as to define a group of closely adjacent Venturi-type orifices whose axes are inclined to the vertical and which are substantially parallel to the axis of the end portion of the casing.

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