An induction-type fluid supply apparatus having an input for primary fluid under pressure, an induction means downstream of the primary input which introduces secondary fluid, and an output downstream of the induction means which emits mixed primary and secondary fluids. Between the primary fluid input and the induction means there is an adjustable valve of the type which, for each adjustment position, will pass fluid at a rate that is constant over a corresponding range of differential pressures. This valve is to be governed by a control device to indicate the rate at which the primary fluid is to be supplied, and means responding to the control device to adjust the valve to different positions. The induction means has a primary orifice through which the primary fluid flows and, adjacent to and downstream of the primary orifice, a secondary orifice through which the secondary fluid flows. Means for oppositely varying the areas of the primary and secondary orifices are provided to change the rate of flow of the induced secondary fluid. In one embodiment the primary and secondary orifices have their areas controlled by adjustable valves interlinked to simultaneously and oppositely change the areas. Flow of primary fluid through the adjustable valve, and flow of secondary fluid into the induction means, are interrelated by means interconnecting the adjustable valve and the means for varying the areas of the primary and secondary orifices. The interconnection, by means of mechanical linkages or reference to a common control, increases the rate of induction as the flow rate of primary fluid is decreased so that the output will be maximum. When the flow of primary fluid is maximum, induction is minimum, or completely closed off.
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INDUCTION SYSTEM HAVING VARIABLE PRIMARY VOLUME AND VARIABLE INDUCTION

BACKGROUND OF THE INVENTION

The field of the present invention relates to fluid supply systems of the induction type, more particularly, to fluid supply systems used to supply heated or cooled air in heating or air-conditioning systems.

In forced air heating or air-conditioning systems it is desirable that the flow of air into any particular area be held at a minimum to reduce the cost of duct work and to reduce noise. Such reduced flow can be accomplished by providing hotter or colder air in the supply which thus has greater ability to alter temperature in the regions to which it is supplied. One problem resulting from reduced flow systems is poor circulation; the low rates of flow are inadequate to distribute the forced air throughout the region served and substantial temperature differences can exist in the region. To improve circulation, reduced flow systems frequently make use of induction to add air in the region to the supplied air to increase the effective flow in the region without increasing flow in conduits and duct work.

Although induction systems have been successful in increasing circulation, they have exhibited the faults of nonuniform flow over the range of primary flow necessary to control temperature. As a result, circulation tends to vary considerably with resultant temperature fluctuation. Furthermore, present induction systems create design problems in preventing backup through the induction input when full forced flow is desired; conditions altering flow resistance downstream of the induction device can result in reduced flow due to leakage in the induction means. Finally, present induction systems are sensitive to pressure fluctuations in the supply air which cause circulation to be erratic and unpredictable.

SUMMARY OF THE INVENTION

Objects of the present invention are to provide an induction-type apparatus which improves uniformity of flow notwithstanding changes in the supply of heated or cooled air, which is relatively insensitive to pressure fluctuations in the air supply, and which eliminates difficulties arising through loss of pressure or volume through induction openings.

According to the invention, the fluid supply apparatus comprises a primary fluid input, induction means downstream of said primary fluid input for the introduction of a secondary fluid, and an output downstream of the induction means for emitting mixed primary and secondary fluids. Between the primary fluid input and the induction means is an adjustable valve for varying the flow of primary fluid to the induction means. The induction means comprises a primary orifice to receive the primary fluid from the adjustable valve, and a secondary orifice to receive secondary fluid. Means are provided to vary the area of the primary orifice to thereby vary the velocity of flow through it and thereby vary the induction of secondary fluid. The means which varies the area of the primary orifice is interconnected through other means, e.g., a mechanical linkage, through the adjustable valve in a manner which reduces induced flow of secondary fluid as flow of primary fluid is increased, and vice versa. Preferably the area of the secondary orifice is varied inversely with the area of the primary orifice so that induction of secondary fluid can be reduced substantially when the flow of primary fluid is at a maximum.

In one highly practical embodiment of the invention, the adjustable valve regulating flow of primary fluid is of the type which, for each adjustment position, will pass fluid at a rate that is constant over a corresponding range of differential pressures between the primary and secondary orifices in the induction means are determined by a rotatable flapper which varies orifice areas inversely as it is rotated, and which has a position closing off the secondary orifice thereby preventing backup there through. The adjustable valve and the flapper are interconnected by means of a mechanical linkage producing the inverse flow relationship between primary and secondary fluids as described above.

In other embodiments of the invention, the primary and secondary orifices have their areas adjusted by means of adjustable valves interlinked to vary their areas inversely as described above; and the means interconnecting the adjustable valves with the means varying the rate of induction comprises a common control regulating separate motor means effecting each such adjustment.

These and other objects and novel aspects of the invention will be apparent from the following description of preferred embodiments.

DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view of one embodiment of the invention; FIG. 2 is a side view, partly in section, of the embodiment of FIG. 1; FIG. 3 is a side view, similar to FIG. 2, of a second embodiment of the invention; and FIG. 4 is a side view, similar to FIG. 2, of a third embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1 and 2 illustrate fluid supply apparatus 10 according to the invention and of the type designed to be installed above a ceiling 12 to supply conditioned air to the room therethrough. The apparatus 10 receives primary fluid P through a conduit 14 from a source of the primary fluid under pressure (not shown). The primary fluid P in the example illustrated is typically air heated or cooled by heating or refrigerating means and pressurized by a blower. The primary air enters the apparatus 10 through an adjustable valve 16 which is of the type which, for each adjustment position, will pass fluid at a rate that is constant over a corresponding range of differential pressures. The preferred valves 16 are of the type more fully described in the U.S. Pat. No. 3,204,664 to Gorchev et al. Briefly, valve 16 comprises a tubular member 18 having a portion of reduced diameter 20 converging in the direction of fluid flow (left to right in FIGS. 1 and 2). A hollow, rounded plunger member 22 rides on a shaft 24 mounted for sliding motion within the tubular member 18. A link 26, pivoted at 28, is connected both to shaft 24 and to an extendible member 30 of a pneumatic motor 32 having a supply line 34 to control the extension of member 30. The position of shaft 24 can be adjusted in the direction of flow by the motor 32, and for each position of shaft 24, valve 16 will pass a different volume flow of fluid. Plunger member 22 is resiliently mounted on shaft 24 by means of a spring (not shown) which offers resistance as plunger 22 is urged within constrained portion 20 by the flow of air through the valve. By proper shaping of the taper of constrained portion 20 with respect to the characteristics of the spring and plunger 22, the valve will operate so as to pass a substantially constant volume of air for an appreciable variety of differential pressures existing across the valve. Because the position of the shaft 24 is adjustable, the valve can be set in different adjusted positions each of which will pass fluid at a rate that is constant over a range of differential pressures.

The flow of primary fluid P through valve 16 is typically determined by means of control devices such as thermostat 36 so that the valve provides a suitable quantity of heated or cooled primary fluid.

Primary fluid P, at the flow rate determined by valve 16, enters a silencing enclosure 38 and proceeds to an induction means 40 which controls the addition of secondary fluid S to the primary fluid P. In the example illustrated in FIGS. 1 and 2, the secondary fluid S is air from the room serviced by the apparatus 10 and admitted to the apparatus 10 through an opening 42 in ceiling 12.

As shown in FIG. 2, induction means 40 comprises fixed baffle 44 and a movable damper or flap 46 which together
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constrict the flow of primary fluid P and define an orifice Op through which the primary fluid flows. Flap 46 also serves to define a secondary orifice Os through which the secondary fluid flows. As illustrated, flap 46 is pivoted on a shaft 48 which is connected to lever 50. By rotating flap 46 about shaft 48, the areas of the orifices Op and Os are varied in an inverse manner, increases in orifice Op producing concomitant decreases in orifice Os, and vice versa. In one position of rotatable flap 46, illustrated by dashed lines at 52, opening 42 is completely closed and orifice Os is completely closed so that no induction of secondary fluid S can take place. The phenomenon of induction takes place, as is well known, through the Venturi effect. Primary fluid P passing through orifice Op has a high velocity and a corresponding low pressure after it passes through the orifice Op. If this pressure is lower than the pressure of the secondary fluid at orifice Os, the secondary fluid S will be drawn in or aspirated into the induction means 40. The amount of induction or aspiration is controlled by varying the areas of the orifices Op and Os by rotating flap 46. The flow of induced secondary air, determined by the position of flap 46, is related to the flow of primary air P by means of an arm 54 connecting slotted lever 50 at the flap to the link 26 at the valve 16. Arm 54 is connected to link 26 on the opposite side of pivot 22 as is the motor extensible member 30, and thus when the motor acts to increase the flow of primary fluid P, it also acts to reduce the flow of induced secondary fluid S, and vice versa. By appropriately correlating rotation of flap 46 with positioning of the plunger 22, it is possible to achieve a reasonably uniform sum of primary and secondary fluids which are emitted from the apparatus 10 as a mixture M through an exit duct 56 in ceiling 12 downstream of the induction means 40. In a typical example, primary and secondary flow rates are adjusted so that when flapper 46 is in position 52 (no induction) 100 percent of available primary fluid is passed by valve 16, and so that when valve 16 is in its minimum position of 50 percent of available flow, flap 46 is positioned to provide an equal volume of induced flow of secondary fluid. It will be appreciated that other percentages can be attained by appropriate manipulation of linkages.

FIG. 3 illustrates apparatus 10A similar to apparatus 10 shown in FIGS. 1 and 2. Corresponding parts in apparatus 10A are given the same numerals as designated in FIGS. 1 and 2 to show the correspondence. Apparatus 10A differs from apparatus 10, however, in the means which interconnect valve 16 and rotatable flapper 46. Instead of the mechanical linkage provided by arm 54, apparatus 10A effects the interconnection by means of a second pneumatic motor 60 having an extensible member 62 connected to slotted lever 50 and a control line 64 which has the same control pressure wherein it is supplied to control line 34 of motor 32. As illustrated, control means or thermostat 36 serves to control both motor 32 and motor 60 to simultaneously bring about increases in flow of primary fluid P through valve 16 accompanied by decreases of induced flow S, and vice versa. Since motors 32 and 60 can be constructed to respond over somewhat different pressure ranges and with different rates, the relationship of primary fluid and secondary fluid can be tailored to specific needs.

FIG. 4 illustrates modified apparatus 10B according to the invention. Again, parts which correspond to those of apparatus 10 are similarly designated. Apparatus 10B differs from apparatus 10 in its induction means 40B which utilizes valves rather than a rotatable flapper 46. Apparatus 10B further includes orifice Os and second orifice Os. As illustrated, the induction means 40B comprises fixed baffles 70 and 72 constricting flow of primary air to an orifice Op. A tapered valve plunger 74 is mounted for sliding motion into and out of the orifice to vary its effective area and the velocity of flow through it. Similarly, orifice Os has a tapered valve plunger 76 mounted for sliding motion into and out of the orifice to vary its effective area. To affect the appropriate relationship of inverse changes in area of orifices Op and Os, and to obtain the appropriate relationship between primary flow and induced flow, the linkage illustrated in FIG. 4 is used. As shown there, arm 54 is connected to the shaft 78 which carries valve plunger 74 so that orifice Op will be opened as the flow of primary air in valve 16 is increased. Arm 54 is also connected to a pivot link 80 having a fixed pivot 82. A bellows 84, haying a pivot 86, is secured at one end to tapered valve plunger 76 and at the other end to pivot link 80. Thus, as orifice Op is opened, secondary orifice Os will be closed, and vice versa. Instead of single orifices Op and Os as have been illustrated, multiple orifices can be used.

Numerous advantages of the invention will now be apparent. By simultaneously varying induction as well as primary fluid flow, a substantially uniform output flow can be attained. By permitting secondary orifice Os to be closed either by flapper 46 or by valve plunger 76, positive cessation of induction can be achieved to prohibit backup at maximum flow of primary fluid. Finally, by specifying valve 16 to be of the constant volume type described above, it is possible to accurately control primary fluid flow despite pressure fluctuations arising in the induction means or beyond to thereby enable substantially constant rates of flow to be attained.

It should be understood that the foregoing description is for the purpose of illustration and that the invention includes all modifications falling within the scope of the appended claims. What is claimed is:

1. Fluid supply apparatus of the induction type comprising an elongate chamber having rectangularly disposed walls defining an elongate passage and having at one end an opening comprising an inlet opening, in one wall at the other end an opening comprising an outlet opening and in the same wall an intermediate opening, a valve housing at the inlet opening of the chamber containing a valve operable to control the flow of primary air into the chamber through the inlet opening, said valve housing embodying a constriction, a valve element located at the upstream side of the constriction such that the valve is operable to close the passage through the housing into the chamber by movement into the constriction, and comprising a spindle fixed to the valve element and extending therefrom in the direction of flow, an arm pivotally connected at one end to the distal end of the spindle and intermediate its ends in an opening in the valve housing, said arm extending from the valve housing, a fixed vane supported transversely of the chamber, said vane extending inwardly at an angle from the wall opposite to that containing the intermediate opening toward said wall containing the intermediate opening and in the direction of flow, the distal edge of said fixed vane terminating close to but spaced from the median plane of the chamber, a movable vane disposed movably of the chamber in confronting relation to the fixed vane on the wall containing said intermediate opening, means pivotally supporting the movable vane on said wall so as to be movable from a position flat against said wall and in said position overlying said intermediate opening to an inwardly extending angular position in which it is symmetrically disposed with respect to the fixed vane, said vanes collectively defining a restricted flow passage for the primary air through which primary air is adapted to flow in the direction of the discharge opening and being so located with respect to the intermediate opening that the secondary air enters the chamber at said restricted portion of the flow passage, a crank arm fixed to the means pivotally supporting the movable vane, a link connecting the distal end of the crank arm to the outer extremity of said arm extending from the valve housing, and a motor pivotally connected to said arm intermediate the link and the pivot operable by angular displacement of said arm to vary the areas of the restricted flow passage and the intermediate opening in inverse proportion.

2. Apparatus according to claim 1, wherein said movable vane operates when completely closing the restricted passage to completely open said intermediate opening.

3. Apparatus according to claim 1, wherein said adjustable valve is of the type for each adjusted position which will pass air at a rate that is constant over a corresponding range of different pressures whereby said apparatus will provide a constant volume of flow of said primary air for uniform induction.