

[54] **INDUCTION UNIT CONTROL SYSTEM**

[72] Inventor: **Alwin B. Newton, York, Pa.**  
 [73] Assignee: **Borg-Warner Corporation, Chicago, Ill.**  
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*Primary Examiner*—Carroll B. Dority, Jr.  
*Attorney*—Donald W. Banner, William S. McCurry and John W. Butcher

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 236/38  
 [51] Int. Cl. ....B60h 1/00  
 [58] Field of Search .....165/16, 40, 123; 236/38, 92

[57] **ABSTRACT**

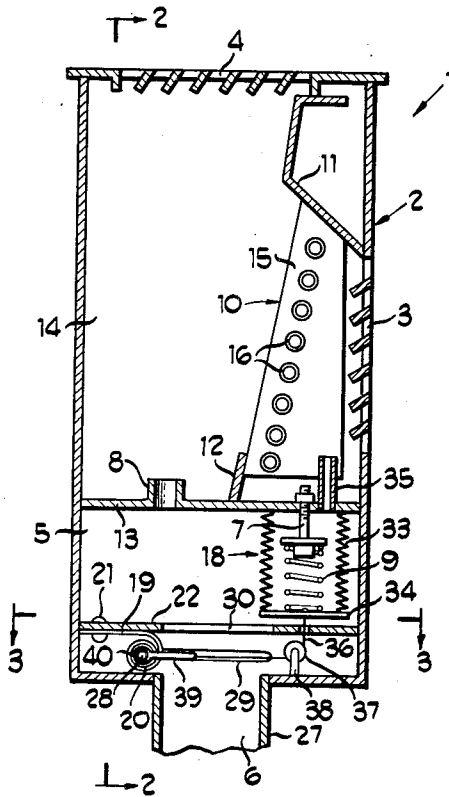
The individual induction units employed in a multi-room air conditioning system are each provided with a damper for varying the flow of the primary air into the induction unit. This damper is automatically controlled in response to the pressure differential across the nozzle plate, that is between the pressure existing inside the primary air supply plenum, and the ambient pressure.

[56] **References Cited**

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**10 Claims, 3 Drawing Figures**



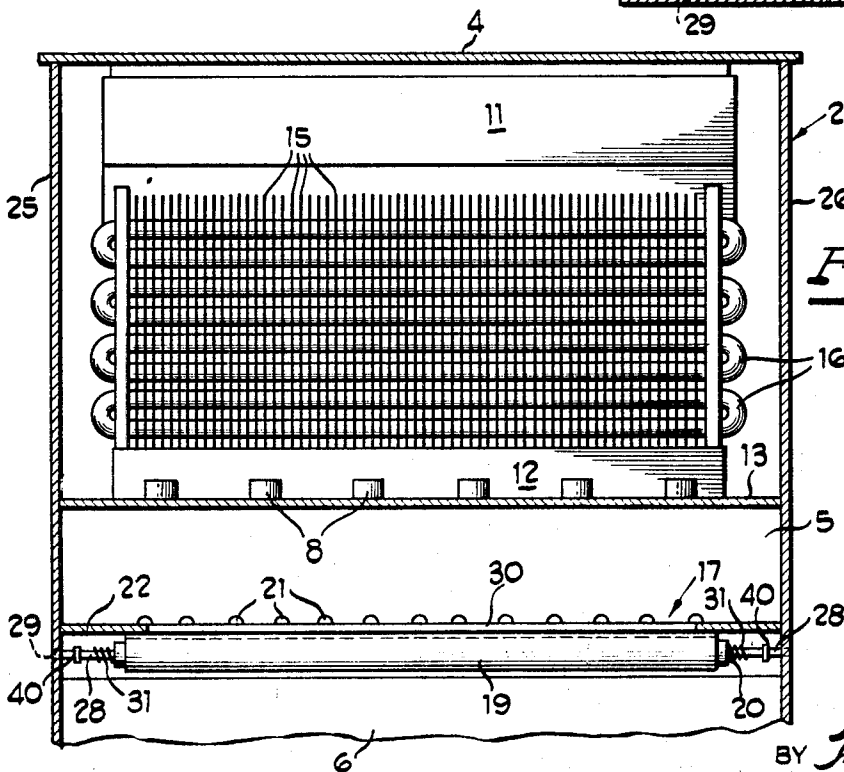
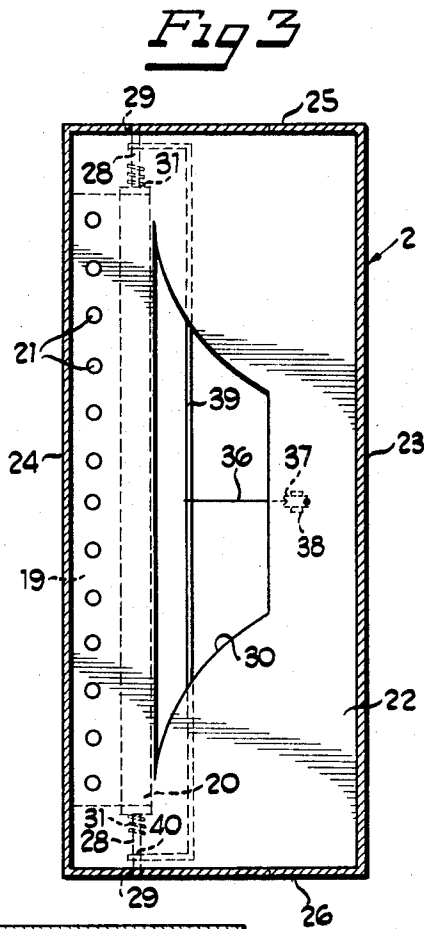
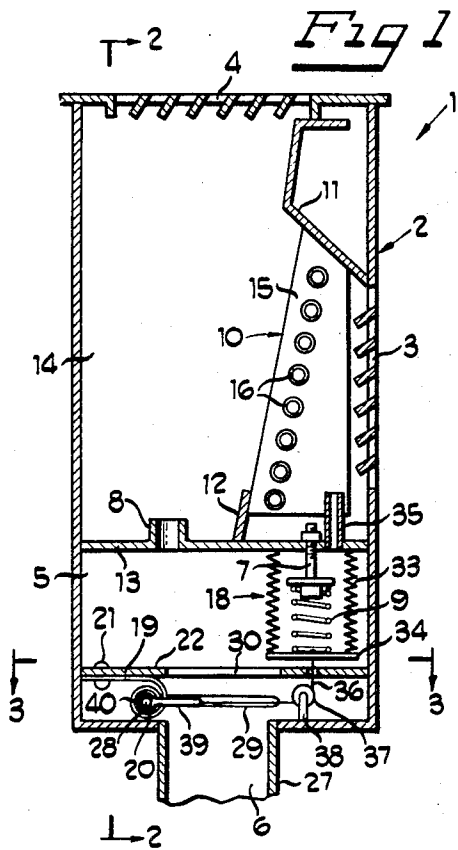


Fig 2

INVENTOR  
ALWIN B. NEWTON

BY *Thomas B. Hunter*  
ATTORNEY

## INDUCTION UNIT CONTROL SYSTEM

## BACKGROUND AND SUMMARY OF THE INVENTION

In the construction of air conditioning systems for high rise buildings, it is common to build the system so that the primary air is delivered within particular zones. For purposes of simplification, assume a 60 story building approximately 600 ft. high. Normal practice would be to provide air conditioning systems for three zones, for example the 0 to 180 ft. level; the 180 ft. to 400 ft. level; and the 400 ft. to 600 ft. level. Under this assumption then, three primary air blowers would be located at the 100 ft., 300 ft., and 500 ft. levels.

One of the problems which has been encountered in the operation of such systems is that there exists a substantial pressure gradient between the first floor and the uppermost floor. Moreover, this pressure gradient is affected further by temperature changes and wind direction and velocity.

In the conventional induction unit system which, for example, is shown in U.S. Pat. No. 2,783,979, the principle by which the system operates is essentially as follows:

Each individual room, or group of rooms, within the building is provided with one or more induction units which comprise a heating (cooling) coil adapted to be supplied with a heated or chilled heat exchange medium, a plenum into which primary air is delivered, a means, such as a nozzle or a group of nozzles, into which the primary air is directed into a mixing chamber at high velocity, thereby creating a low pressure zone downstream from the nozzles and, finally, an opening in the housing into which room air is drawn by means of the low pressure zone, and caused to circulate over the coil and back into the room. The normal operation of these units is to provide cool primary air in the winter, while supplying a heated medium to the coil. In the summer, warm primary air is supplied to the units, while a chilled medium is circulated through the coil.

If it were not for the fact that the pressure gradient changes under different conditions such as those mentioned earlier, each of the individual induction units could be set for the particular condition existing at that point and left alone to operate satisfactorily. However, because of the pressure gradient changes, this causes imbalance in the units, and unless they are constantly being adjusted, there are changes in the operation of the induction units which create insufficient or too much heating or cooling at different times.

The present invention proposes to solve this problem by the use of individual dampers automatically controlled so as to maintain a predetermined pressure differential across the nozzle plate, that is, from the plenum to the mixing chamber. This damper is of a low cost, simplified design, and can be added to existing units with very little expense. The damper is in the form of a screen which is adapted to control the flow of air into the plenum chamber by opening and closing a port on the inlet side of the plenum. The position of the screen may be controlled by a simple pneumatic actuator, such as a bellows, operated through a system of levers or mechanical linkages.

It is, therefore, a principal object of this invention to provide an improved induction unit control system for a multi-room air conditioning system.

Another object of the invention is to provide an improved damper assembly for use with an induction unit system.

Additional objects and advantages will become apparent from reading the following description taken in conjunction with the drawings.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a transverse cross-sectional view of an induction unit having a primary air supply control constructed in accordance with the principles of this invention;

FIG. 2 is a longitudinal sectional view of the induction unit of FIG. 2; and

FIG. 3 is a detailed, cross-sectional view of the damper control system.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, the air conditioning unit 1 is of the induction type usually placed beneath the window of a room being treated. The unit comprises a casing 2 having an inlet opening 3 and an outlet opening 4, each opening consisting of a series of louvered openings through which a stream of secondary air is induced into the unit and a mixture of primary and secondary air is discharged from the unit. A heat exchange member 10 is supported on brackets 11 and 12 on the casing 2.

The air conditioning unit also has a plenum 5 located at the bottom portion of the casing 2 and consists of an elongated chamber extending the length of the casing and having an air inlet 6 through which primary air passes into the plenum. This primary air is supplied under pressure from a blower (not shown) located at a central station. The air is directed into plenum 5 and is discharged therefrom through the nozzles 8 into the mixing chamber 14.

The nozzles 8 may be of several known types, but in the embodiment illustrated, they comprise a plurality of openings in a plate 13 extending the length of the casing 2 and through which air is passed to the mixing chamber 14 above the plenum. When air passes through the nozzles, the Bernoulli effect draws secondary air from the room through the opening 3 and into the chamber 13 where the primary and secondary air streams are then mixed.

Located above the plenum 5 and the nozzle plate 13 is the heat exchange member 10 comprising a plurality of parallel, extended fins 15 and a plurality of tubes 16 connected into a single circuit through which a heat exchange medium is passed. The fins 15 are attached to these tubes and act as an extended surface thereof. The aforementioned heat exchange medium originates from a central station of the air conditioning system and may consist of either hot or cold water.

As the primary air is discharged from the nozzles 8, secondary air is induced through the opening 3 from the room and is mixed with the primary air and this air mixture flows through the heat exchange member 10 and is thereby placed into heat exchange relation with the medium passing through the tubes 16. The treated air mixture is then discharged through the outlet 4 into the room.

Referring to FIG. 1, it will be noted that the primary air, passing into inlet 6 and through plenum 5, is caused by the nozzles 8 to be expelled at high velocity into mixing chamber 14 thereby creating a low pressure zone downstream from the nozzles. By reason of the created low pressure zone, the secondary room air is drawn through opening 3 into the mixing chamber, the primary and secondary air mixture circulating over the heat exchange coils and back into the room. In normal operation, these units provide cool primary air in the winter, while supplying a heated medium to the coil 16. In summer, warm primary air is supplied to the units and a chilled medium is circulated through the coil 16.

Air conditioning systems of the induction unit type described are conventionally employed in tall buildings with the primary air delivered by individual air conditioning systems provided in zones vertically spaced in the building. In this arrangement, a substantial pressure gradient exists between the first floor and the uppermost floor of each zone. Furthermore, this pressure gradient is also affected by temperature changes and wind direction and velocity. More particularly, an analysis of "stack effect" pressure changes within high rise buildings shows that the difference between ambient or secondary air pressures at a point more than 8 or 10 stories above or below the primary air source fan room and the ambient pressure at the fan room causes problems by upsetting the ratio of primary to secondary air pressures within the induction units. Since the ambient secondary air pressure varies in one direction as the heating season becomes more severe, and in the opposite direction as the cooling season becomes more demanding, no single setting of a manually adjusted

damper in each induction unit is satisfactory for producing the desired primary air pressure to compensate for the changes in the ambient air pressure gradients.

The present invention provides a solution to this problem by employing means for automatically controlling the primary air pressure in the individual air conditioning induction units relative to the surrounding ambient air and more particularly by employing a control device for a damper which is automatically operative to vary the position of the damper to regulate the flow of air into the plenum chamber by opening and closing a port on the primary air inlet side of the plenum.

The improved induction unit control system comprises a damper 17 and damper control device 18. The damper 17 is positioned at the bottom of the plenum 5 and includes a screen or curtain 16 provided by an elongated, flexible, impermeate sheet of suitable material wound about a shaft or roller 20 and having one end portion fastened by mechanical holding means, such as rivets 21, to a plate 22 extending between and connected, as by welding, to the front and rear walls 23 and 24 and side walls 25 and 26 of the casing 2. As seen in FIG. 3, the plate 22 is located in the plenum 5 and forms a partition between the primary inlet air duct 27 and the nozzle plate 13.

The roller 20 has end trunnions 28 received in slots 29 in the side walls 25 and 26 of the casing 2 for supporting the roller and for movement of the roller between the front and rear walls 23 and 24 of casing 2 to wind and unwind the curtain on the roller to provide for adjustable partial covering of a generally frustoconical opening or port 30 in the plate 22 to thereby vary the area of the opening and consequent control of flow of primary air from the duct 27 into the plenum chamber 5.

Movement of the roller 20 is controlled by torsion springs 31 at both ends of the roller which have one end connected to the roller and its other end connected to the trunnions 28. The springs 31 are operative to bias the roller in a direction tending to wind the curtain 16 on the roller and to the open position shown in the drawing.

The control device 18 is provided to automatically regulate movement of the roller to vary the position of the damper curtain and thereby the opening and closing of the port 30 by the curtain to control the flow of primary air into the plenum. More particularly, the control device 18 comprises an axially extensible bellows 33 having its lower end wall sealed around and fixed to a circular disk 34, the upper circular end of the bellows being sealingly connected to the bottom of the nozzle plate 13 to prevent primary air in plenum chamber 5 entering the bellows. The plate 13 is provided with an opening receiving an air tube 35 connecting the bellows chamber with chamber 14 to permit secondary air in chamber 14 to flow to and from the bellows. A coiled compression spring 9 is located in the bellows with its lower end seated against the disk 34 and its upper end engaging a washer-like head of a bolt 7, the bolt extending upwardly through the plate 13 and being threaded into plate 13 and rotatable to vary the compression of spring 9. A flexible wire or cable 36 is secured to the center of the disk 34, extends downwardly through an opening in plate 22, and engages a pulley 37 rotatably supported on a bracket 38 secured to the casing 2 as shown in FIG. 1. The wire 36 extends horizontally from the pulley 37 and is connected to a rigid U-shaped frame 39 intermediate the ends thereof, the frame having the loop ends of its legs 40 surrounding the trunnions 28 of the roller 20 for moving the roller toward the damper-closing position of the curtain 19.

As previously explained, the rise and fall of the ambient room air pressures between the first floor and uppermost floor in high rise buildings during winter and summer, coupled with other pressure gradient changes attributable to temperature changes and wind direction and velocity, can create an imbalance in the induction units causing undesirable operational changes in the units and thus providing insufficient or too much heating or cooling at different times. It should be noted that the difference in temperature between the air in the duct

and the ambient within the building also creates a disturbing pressure gradient which requires the damper control of the present invention.

To solve this problem and referring to the operation of the damper control device 18 in the preferred embodiment of the invention, the bellows 33 provides a pneumatically operated pressure regulator responsive to variations in ambient air pressure entering opening 3 in the casing 2 and flowing into the chamber 14. The device is arranged to automatically effect adjustment of the damper in a manner to compensate for such variations to thereby maintain a constant pressure in the chamber 14 relative to the surrounding ambient air pressure. More particularly and referring to the drawing, primary air is directed at high velocity through duct 27 and port 30 of plate 22 and into the plenum chamber 5 and then through the nozzles 8 into the mixing chamber 14. At the same time, a low pressure zone is created downstream of the nozzles in chamber 14 causing secondary room or ambient air to be drawn into the chamber 14 and to mix with the primary air, the air mixture circulating over the coils 16 and exiting through louvered openings 4 into the room.

Assuming changes occur in the ambient or room air pressure, the bellows 33 senses the differential between the primary air (plenum) pressure and ambient pressure and adjusts the damper curtain 22 to regulate the flow of the primary air to maintain a constant differential between the primary air pressure and the ambient pressure, namely, to provide an air pressure in plenum 5 which is constant relative to ambient air pressure at opening 3 of the casing 2. As the tube 35 vents the bellows to the ambient pressure at opening 3, a fall in ambient pressure at opening 3 will cause the bellows to contract and pull cable 36 and frame 39 to move the roller to unroll the curtain 22 over the port 30 and thereby reduce the primary air flow through the port and into the plenum 5; and, conversely, a rise in the ambient pressure at opening 3 will cause the bellows to expand so that the torsion springs 31 will provide a restoring force to the roller to re-roll the curtain and thereby withdraw the curtain over the port 39 to increase the flow of air through the port into the plenum 5. Accordingly, plenum 5 always retains essentially the same nozzle pressure in any induction unit regardless of the location of the unit in the building and irrespective of the level of the unit in relation to the primary air source. The result is more uniform control of heating and cooling. Furthermore, since the pressure gradient within the supply ducts serving the different levels, such as the 0 to 180 ft. level, the 180 ft. to 400 ft. level, etc., varies within each duct system, the supply pressure at 6 in the various units in the building will be different. This would result in a different flow and different pressure within the supply plenum were it not for the action of the bellows and damper which corrects for these changes in supply pressure.

For the purpose of varying the desired pressure in plenum 5, the pressure of spring 9 in bellows 33 may be changed by rotating the bolt 7 to move the bolt down or up to increase or decrease the compressive force of the spring acting on the disk 34.

While the invention has been described in connection with a certain specific embodiment thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of the appended claims should be construed as broadly as the prior art will permit.

What is claimed is:

1. In an air conditioning unit, the combination of a casing (2); a partition (13) in said casing and providing a plenum chamber (5) and a mixing chamber (14); means defining a first inlet (6) in said casing for primary air under constant pressure and communicating with said plenum chamber; means defining a second inlet (3) in said casing for ambient secondary air from the area being conditioned and communicating with said mixing chamber; means defining an outlet (4) in said casing and communicating with said mixing chamber; nozzle means (8) provided by said partition and connecting said chambers whereby the discharge of primary

air through said nozzle means and into said mixing chamber induces a stream of secondary air through said second inlet to mix with the primary air discharged from the plenum chamber, the mixture being discharged through said outlet; a heat exchanger (10) disposed in said mixing chamber; a plate member (22) supported in said casing and providing an air port (30) communicating said first inlet with said plenum chamber; a damper assembly (17) including a curtain (16), means (20, 21, 28, 29) for mounting said curtain on said plate member at one side of said air port and for movement of said curtain over said air port to thereby vary the flow of primary air to said nozzle means; spring means (31) biasing said curtain to open said air port; and means (18) automatically-controlling movement of said curtain over said air port including an expansible and contractable bellows (33) in said plenum chamber having one end fixed to said partition and a movable wall 34 coupled to said curtain at the other side of said air port for moving said curtain; and a tube (35) extending through said partition and communicating with the interior of said bellows and having its inlet located in the ambient secondary air entering said second inlet (3) to control movement of said movable wall in response to varying pressure of the ambient secondary air.

2. An air conditioning unit according to claim 1 in which said curtain mounting means (20, 21, 28, 29) includes a roller (20) having its ends (28) supported on spaced walls (25, 26) of said casing (2), and for movement toward said bellows (33), said curtain being wrapped around said roller and having one end connected to said plate member (22), said roller ends (28) being also connected to said movable wall of said bellows (33) whereby movement of said movable wall (34) is operative to move said roller toward said bellows to unwrap said curtain from said roller to open and close said air port (30) to change the flow of primary air into said plenum chamber (5).

3. An air conditioning unit according to claim 2 in which said spring means are tension springs (31) connected to said roller ends (28) and to said casing (2).

4. An air conditioning unit according to claim 2 in which a U-shaped frame (39) is connected to said movable wall with its spaced arms (40) connected to said roller ends (28).

5. An air conditioning unit according to claim 4 in which a pulley (37) is supported on said casing (2), below said bellows (33), and a flexible cable (36) engages said pulley and has its opposite ends connected to said frame (39) and said movable wall.

6. An air conditioning unit according to claim 1 in which a

spring (9) is positioned in said bellows (33) to expand said bellows in opposition to the contractive effort exerted on said bellows by air pressure changes in said bellows.

7. An air conditioning unit according to claim 6 in which said spring (9) is a compression coil spring having one end engaging said movable wall said bellows (33), and an adjusting member (7) of one end engaging the other end of said spring, the other end of said adjusting member having threaded engagement with said partition (13) and being rotatable to move said adjusting member to vary the compression of said spring.

8. In an air conditioning unit, the combination of a casing (2); a partition (13) in said casing and providing a plenum chamber (5) and a mixing chamber (14); means defining a first inlet (6) in said casing for primary air and communicating with said plenum chamber; means defining a second inlet (3) in said casing for ambient secondary air from the area being conditioned and communicating with said mixing chamber; means defining an outlet (4) in said casing and communicating with said mixing chamber; nozzle means (8) provided by said partition and connecting said chambers whereby the discharge of primary air through said nozzle means and into said mixing chamber induces a stream of secondary air through said second inlet to mix with the primary air discharged from the plenum chamber, the mixture being discharged through said outlet; a heat exchanger (10) disposed in said mixing chamber; a damper (17) positioned in said casing and operative to vary the flow of primary air into said plenum chamber, said damper (17) including a curtain (16) movable transversely of the primary air flow and spring means (31) biasing said curtain (16) in a direction transversely of the primary air flow; and means (18) for automatically controlling operation of said damper in response to difference in the pressures in the primary air existing in said plenum chamber and ambient secondary air entering said second inlet (3), said automatic controlling means operative to move said curtain in a direction opposite to that of the biasing force exerted by said spring means (31).

9. An air conditioning unit according to claim 8 wherein said automatic control means (18) is a pneumatically operated device.

10. An air conditioning unit according to claim 9 in which said primary air is under substantially constant pressure, said automatic controlling means (18) for said damper (17) being responsive to pressures of the ambient secondary air entering said second inlet (3).

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,650,320 Dated March 21, 1972

Inventor(s) Alwin B. Newton

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 6, after "wall" insert -- (34) of -- ;  
line 7, cancel "of" , first occurrence, and insert -- having --

Signed and sealed this 31st day of October 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

ROBERT GOTTSCHALK  
Commissioner of Patents