Title: PNEUMATIC ANIMAL CONFINEMENT HOUSE AIR INLET ACTUATION SYSTEM AND METHOD

Abstract: A system and method for improving the actuation of vent doors in poultry houses and other animal confinement houses is claimed. The system reduces the number of pulleys and other moving parts and increases the system reliability by replacing high-maintenance motor-operated ball screw gear drives with pneumatic cylinders that move a control line to open and close the vent doors. The system provides for variable speed of the vent door actuation and reduces the number of bends in the control line cables.
PNEUMATIC ANIMAL CONFINEMENT HOUSE AIR INLET ACTUATION SYSTEM AND METHOD

by

Dale A. Beauchamp,
Inventor

LANIER FORD SHAVER & PAYNE P.C.
200 West Side Square Suite 5000
Huntsville AL 35801

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Pneumatic Animal Confinement House Air Inlet Actuation System and Method

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Provisional Patent Application U.S. Serial Number 60/732,945, entitled "Pneumatic Animal Confinement House Air Inlet Actuation System and Method" and filed on November 3, 2005, which is fully incorporated herein by reference. This application also claims priority to the U.S. Non-Provisional patent application filed on November 2, 2006, entitled "Pneumatic Animal Confinement House Air Met Actuation System and Method."

BACKGROUND AND FIELD OF INVENTION

[0002] The present invention relates generally to a system and method for operating air inlets and/or curtains in poultry houses and other animal confinement buildings. More particularly, the present invention relates to a system and method for pneumatic operation of animal confinement house air inlets or curtains that improve upon the prior art by reducing moving parts and increasing the reliability of the actuation system.

[0003] In modern poultry houses and other animal confinement facilities life support inputs are supplied by mechanical means manipulated by the production manager by way of inputting the proper programming parameters into a computerized control system. One of the functions of these control system is to control the static air pressure (i.e. vacuum) inside the production house. Static pressure is the difference between the outside air pressure (atmosphere) and the inside air pressure during ventilation of the production facility (normally measured in inches of water column or millimeters of mercury, etc.) Achieving proper static pressure is critical to optimum performance of the flock of chickens and thus maximum profits for both grower and integrator.
To achieve the air exchange required during ventilation to maintain the proper static pressure, air inlets or "vent doors" are incorporated in the upper sidewalls close to the ceiling or in the ceiling of the poultry house. These vent doors open to the outside atmosphere and allow fresh oxygen-rich air to be introduced to the poultry house. The vent doors are generally spaced at regular intervals down the length and on either side of the poultry house, the length of which ranges normally from 400 feet to 600 feet with a width of normally 40 feet to 60 feet or more.

Vent door shapes and sizes vary among applications but in many applications are about 7-\(\frac{1}{8}\)" x 52" and are hinged at the bottom, if mounted in the side wall, or, if in the ceiling, are hinged at the edge closest to the side wall. The vent doors open to the outside atmosphere to allow fresh air to be drawn into the enclosed area by exhaust fans mounted into the walls of the house. The fans establish the required negative air pressure, or vacuum, inside the house.

Not only do the vent doors allow fresh air into the poultry house, they also direct the flow of the air in the desired direction and velocity. In winter, for example, if the vent doors are opened too wide, the cool air from the outside will sink to the floor rapidly, causing cold drafts. If the vent doors are adjusted correctly, the cool air will enter the poultry house in the proper direction and velocity so that it travels along the ceiling of the house until it reaches the midpoint of the structure and starts falling toward the floor. The interval that the cool air travels along the ceiling allows it to pick up heat so that the birds do not get chilled when the cool air falls. This difference between properly adjusted and improperly adjusted vent doors is illustrated in FIG. 1.
In today's animal confinement and poultry houses the construction techniques are far superior to days of the past. The structures are more air-tight; and, in some applications, all of the life-sustaining oxygen is introduced through the vent doors alone. Therefore, proper vent door adjustment is critical to the health of the animals.

The vent doors (also known as air inlets) are opened and closed by means of an air inlet actuation system. The air inlets are generally hinged at the bottom and connected at the top of the inlet to a common control line by way of nylon cord that is trained around small pulleys attached to the wall above the air inlet. The actuation systems used today incorporate a series of cables and pulleys to achieve the linear motion of the control line, and the cables moving around this network of pulleys fail on a regular and predictable basis.

Most prior art vent door actuation systems use motor-operated ball screw gear drives to move cables that connect via pulleys and strings to the vent doors. A prior art actuation system is described in detail in the owner's manual to the PowerTrak Curtain/Vent Actuator, Part No. 4801-0154, dated January 1998. (This owner's manual can be found at http://www.hhgreen.com/download/PowerTrakman.pdf.) As is described in this manual on page 8, regular lubrication of parts within the prior art actuation system is "crucial" to its continued operation.

In addition, the prior art actuation systems do not allow for varying the speed of the opening/closing operations of the vent doors. A user has to either adjust the pulley arrangement or replace the motor in the gear drive in order to change the speed of the actuation, and those operations serve only to change the speed to another constant speed (i.e., do not provide the ability to vary the speed).
Use of the prior art vent door actuation systems (whose designs date back twenty (20) years or more) with the more air-tight poultry houses of modern times can cause regular failures in the process of simply moving the vent door trunk line (the cable that runs along the length of the poultry house and pulls the vent doors open) in a linear motion, i.e., straight line. The increasing number of failures is due to the added cumulative pressure on the large number of vent doors. Most of the failures are of the gear motor and load blocks, which strain against the pressure difference. In addition, cables are attached to the load block and are routed around numerous pulleys to achieve various speed and strength ratios, and the cable work also fails on a regular basis.

Curtains are used instead of vent doors in some poultry houses, and are used in addition to vent doors in some poultry houses. Controlling the opening and closing of curtains is similar to opening and closing vent doors, except that a longer "stroke" is required because the curtains may need to be raised by as much as five feet.

It would be desirable to have a vent door/curtain actuation system that reduces the numbers of pulleys and other moving parts in order to provide a lower maintenance, more reliable system. It would also be desirable to have a vent door/curtain actuation system that permits variable speed actuation of both the opening and closing of the vent doors independently.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a vent door actuation system that reduces the number of pulleys and other moving parts required for actuation.
It is a further object of the invention to provide a vent door actuation system that permits variable speed actuation of both the opening and closing of the vent doors independently.

It is a further object of the invention to provide a vent door actuation system that reduces the number of bends in the control line cables, in favor of a more straight line operation.

It is a further object of the invention to provide a vent door actuation system that does not require periodic lubrication and thus reduces maintenance on the system.

The present invention eliminates all the gear motors, gear boxes, numerous switches, and minimizes the number of pulleys and other moving parts. The invention utilizes off-the-shelf parts including a pneumatic cylinder that moves back and forth on command. The speed of the cylinder is adjustable independently during both the open and close cycles.

In some embodiments of the present invention, the pneumatic vent door actuation system incorporates true linear motion with the bare minimum of moving parts by utilizing a single double-rodded pneumatic cylinder per side of the animal confinement house. The control line is attached in a straight line with the double rodded cylinder thus eliminating the multiple training-around pulleys. The far end of the control line is attached to large springs which maintain a tension in the line. The tension springs oppose each other in this system, thus achieving a near-zero net load on the cylinder. By minimizing the load on the pneumatic actuation system, the useful life span of the actuation system is prolonged.
For purposes of summarizing the invention, certain aspects, advantages, and novel features of the invention have been described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any one particular embodiment of the invention. Thus, the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

These and other embodiments of the present invention will also become readily apparent to those skilled in the art from the following detailed description of the embodiments having reference to the attached figures, the invention not being limited to any particular embodiment(s) disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

FIG. 1 shows the difference in air circulation in an animal confinement house with properly- versus improperly-adjusted vent doors.

FIG. 2 shows a side-wall of an animal confinement house containing a prior art vent door actuation system.

FIG. 3 illustrates one embodiment of the present invention installed in a side-wall of an animal confinement house.
FIG. 4 is a bottom view of the inner ceiling of an animal confinement house showing one embodiment of the vent door actuation system.

FIG. 5 is a partial side view of one embodiment of the invention.

FIG. 6 is a bottom view of the inner ceiling of an animal confinement house showing an embodiment of the vent door actuation system utilizing two single-rodded cylinders.

FIG. 7 illustrates an embodiment of the present invention utilizing a single-rodded cylinder installed in a side-wall of an animal confinement house.

DETAILED DESCRIPTION OF THE INVENTION

The present invention and its advantages are best understood by referring to the drawings. The elements of the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the invention. Throughout the drawings, like numerals are used for like and corresponding parts of the various drawings.

FIG. 2 illustrates a prior art system installed in the interior sidewall 6 of a poultry house for actuating the vent doors 1. In this prior art system, the vent doors 1 are actuated via a motor-operated ball screw gear drive 2. The vent doors 1 in this prior art system are hinged at their bottoms and connected to a common control line 4 by way of nylon cord 7. The term "control line" as used in this specification refers to the generally horizontal cord that runs above the vent doors. Axial movement of the control line causes the vent doors to open and close. These nylon connection cords 7 are generally trained around small pulleys 8 and fixedly attached to the top of the vent door 1. The small pulleys
8 are attached to the wall 6 above the vent door. The prior art actuation system incorporates a series of cables 9 and large pulleys 3 to achieve the axial motion of the control line 4. The ends of the control line 4 are connected to the wall 6 via large springs 12. Unfortunately, the movement of the cables 9 over the large pulleys 3 causes the cables to wear and fail on a regular basis. By incorporating an actuation system which eliminates many of the cables and pulleys and achieves true linear motion, the present invention minimizes production and repair problems.

[0032] One embodiment of the present invention, illustrated in FIG. 3, improves upon the prior art by allowing a true linear axial motion of the control line 4 with a minimum of pulleys and other moving parts. In this embodiment, the actuation device is a single double-rodded pneumatic cylinder 10 installed in a straight line with the control line 4. The double rods 11 of the pneumatic cylinder 10 move back and forth in an axial direction to move the control line 4, thus eliminating the multiple large pulleys necessary in the prior art system. The pneumatic cylinder 10 does not require any lubrication or other periodic maintenance by the user.

[0033] In this embodiment, the far ends of the control line 4 are attached to the wall 6 through large springs 12 which maintain a tension in the line. These tension springs 12 oppose each other in the system, thus achieve a net load of almost zero on the pneumatic cylinder 10. The low load on the cylinder helps to extend its useful life span and thus the reliability of the actuation system. The tension in the springs 12 can be adjusted manually via hand winches 18 that are connected to the springs 12.

[0034] In this embodiment of the invention, the pneumatic cylinder 10 and its control system 19 are all comprised of commercial off-the-shelf parts. The control system
components are usually located in a control room outside of the animal confinement area. The pneumatic cylinder 10 is controlled via standard a two-way air control valve 13 connected to the pneumatic cylinder 10 through air lines 14. The air control valve 13 receives electrical signals to open or close from a static pressure control unit 15. A standard air compressor 17 provides pressurized air to the pneumatic cylinder 10 through a regulator 16 and the air control valve 13. In multiple-house applications, a large central air compressor can be used.

At the beginning of a ventilation cycle, exhaust fans (not illustrated) are activated to produce a static pressure (vacuum) in the house. When the static pressure control unit 15 reads a negative pressure in excess of its predetermined target value it sends a signal to open the vent doors 1 to allow fresh air into the house, decreasing the static pressure and effecting air exchange. When the static pressure rises to the desired level, the vent doors 1 are stopped in a fixed open position. At the end of the ventilation cycle, the fans are turned off and the static pressure drops to zero (i.e., the inside pressure equals the outside pressure). When the static pressure controller 15 reads a static pressure of less than the target pressure it sends an electric signal to close the vent doors.

In this embodiment of the invention, the speed of the actuation can be easily varied by adjusting exhaust mufflers 22 on the air control valve 13. Because air is exhausted from the opposite sides of the cylinder during extension and retraction, the speed of both the open and close cycles can be varied independently of each other by separately adjusting the exhaust mufflers 22 to different speeds. In other embodiments of the invention, the actuation speed is controlled by adjusting a flow control valve located on the exhaust or inlet lines to the cylinder.
In the embodiment illustrated in FIG. 3, one pneumatic cylinder 10 would be installed per sidewall 6 of the animal confinement house, though other configurations may be used for other applications. For example, in some types of animal confinement houses only one wall of the house contains vent doors, and therefore only one pneumatic cylinder and actuation system would be needed for the entire house. For houses with two or more walls of vent doors, the actuation of the two or more pneumatic cylinders may be synchronized so that the vent doors open and close at the same time on both sides of the house.

In other embodiments of the present invention, one pneumatic cylinder may be used to actuate both sides of vent doors, as illustrated in FIG. 4, a bottom view of the actuation system in an animal confinement house. In this embodiment, chains 20 and sprockets 21 replace the large pulleys used in the prior art. This chain/sprocket arrangement reduces wear on the control line 4. Although chain/sprocket arrangements are known in the art of animal confinement house ventilation design, they have not previously been coupled with a pneumatic cylinder-driven system as described herein.

In the embodiment shown in FIG. 4, the pneumatic cylinder 10 is mounted on the ceiling 30 of the house. As can be seen in FIG. 4, the cylinder 10 and control line 4 are oriented at a perpendicular angle to one another in this embodiment. In order to make the ninety-degree turn, two chains 20 connected to each side of the pneumatic cylinder 10 move over two pairs of sprockets 21 connected to opposite walls of the house. As illustrated in FIG. 5 (a partial end view of the house), another chain 20/sprocket 21 combination can be installed near the pitch 24 of the ceiling 25 to keep the control line 4 close to the ceiling and to compensate for the difference in ceiling slopes on either side of the center line of the house.
house. In other embodiments of the invention, a cable/pulley combination can be used in lieu of the chain/sprocket combination to make the require turns of the control line.

[0040] Although the embodiments illustrated herein showed vent doors located on the upper walls of the poultry house, the system would work equally well with vent doors located on the ceiling. Further, the control line may be installed on the ceiling instead of the walls of the poultry house.

[0041] As an alternative to a double-rodded cylinder, one or more single-rodded cylinders may be used to control the vent door opening and closing. FIG. 6 illustrates a bottom view of an embodiment of the invention incorporating two single-rodded cylinders 40. The operation of this configuration is similar to that of the embodiment illustrated in FIG. 4, except that the two single-rodded cylinders used in the embodiment illustrated in FIG. 6 are separately and independently controllable.

[0042] FIG. 7 illustrates an embodiment of the invention using a single-rodded cylinder 10 to actuate vent doors on one wall of a poultry house. In this embodiment, the cylinder 10 is installed at one end of the control line 4 in a straight line with the control line 4. Spring 12 is connected to the other end of the control line 4 to maintain tension on the line.

[0043] The actuation system of the present invention can be used to raise and lower curtains in the same manner that it opens and closes vent doors. A longer stroke from the cylinder is required, and therefore cylinders providing such a longer stroke are used in curtain actuation systems.
In very large poultry houses in which the venting of different "zones" are desired to be controlled separately, multiple cylinders may be used for actuating the different zones, and the cylinders are controllable independently from each other. In large poultry houses where independent control of zones are required and as well as other applications, the system and method of the present invention utilizes a cylinder that provides the capability of monitoring cylinder position through the entire stroke range of the piston rod. This "continuous position feedback" cylinder provides feedback to the controller so that the controller knows the exact position of the piston rod - and thus the exact position of the vent doors - at all times. The continuous position feedback cylinder operates using a linear resistive transducer, which is a position sensor that uses a resistive element to provide a continuous analog output signal relative to the cylinder's position.

This invention may be provided in other specific forms and embodiments without departing from the essential characteristics as described herein. The embodiment described is to be considered in all aspects as illustrative only and not restrictive in any manner. The following claims rather than the foregoing description indicate the scope of the invention.

As described above and shown in the associated drawings and exhibits, the present invention comprises a method and apparatus for an improved vent actuation system for animal confinement houses. While particular embodiments of the invention have been described, it will be understood, however, that the invention is not limited thereto, since modifications may be made by those skilled in the art, particularly in light of the foregoing teachings.
WHAT IS CLAIMED IS:

1. A method for improving the actuation of animal confinement house ventilation devices, comprising the steps of:
   a. installing a substantially horizontal control line along at least one wall or ceiling of an animal confinement house;
   b. connecting animal confinement house ventilation devices to the control line such that axial motion of the control line can cause the animal confinement house ventilation devices to open and close;
   c. installing a pneumatic cylinder with at least one piston rod on a wall of the animal confinement house in a generally straight line with the control line;
   d. connecting the piston rod to the control line so that a stroking movement of the piston rod causes axial motion of the control line;
   e. providing control means for independently controlling the speed of the opening and the closing of the animal confinement house ventilation devices so that the opening of the ventilation devices may be performed at a speed variable from the speed of the closing of the devices.

2. The method of claim 1, wherein the animal confinement house ventilation devices comprise vent doors or curtains.

3. The method of claim 1, wherein the control means automatically controls the opening and the closing of the ventilation devices when certain predetermined pressure or temperature levels are reached.

4. The method of claim 1, wherein the cylinder is capable of providing substantially continuous feedback to the control means regarding the position of the piston rod.
5. A method for improving the actuation of animal confinement house ventilation devices, comprising the steps of:
   a. installing a control line along at least one wall or ceiling of an animal confinement house;
   b. connecting animal confinement house ventilation devices to the control line such that axial motion of the control line can cause the animal confinement house ventilation devices to open and close;
   c. installing a pneumatic cylinder with a piston rod at a substantially ninety-degree angle to and connected to the control line through a chain and sprocket device so that a stroking movement of the piston rod causes axial motion of the control line;
   d. providing control means for independently controlling the speed of the opening and the closing of the animal confinement house ventilation devices so that the opening of the ventilation devices may be performed at a speed variable from the speed of the closing of the devices.

6. The method of claim 5, wherein the animal confinement house ventilation devices comprise vent doors or curtains.

7. The method of claim 5, wherein the cylinder is capable of providing substantially continuous feedback to the control means regarding the position of the piston rod.

8. A straight-line actuation system for controlling the opening and closing of animal confinement house ventilation devices, comprising:
   a. a control line connected to animal confinement house ventilation devices;
   b. a pneumatic cylinder that imparts axial force upon at least one piston rod, wherein the at least one piston rod is connected to the control line;
a controller capable of causing the at least one piston rod to stroke outward at a speed independently variable to the rod's inward stroke, in order to independently control the speed of the opening and the closing of the animal confinement house ventilation devices so that the opening of the ventilation devices may be performed at a speed greater than or less than the speed of the closing of the devices.

9. The system of claim 8, wherein the animal confinement house ventilation devices comprise vent doors or curtains.

10. The system of claim 8, wherein the at least one piston rod comprises two piston rods on opposite ends of the pneumatic cylinder.

11. The system of claim 8, wherein the piston rod is oriented in a substantially straight line with the direction of movement of the control line.

12. The system of claim 8, wherein the piston rod is oriented at an angle to the direction of movement of the control line.

13. The system of claim 12, wherein the angle is substantially ninety degrees.

14. The system of claim 8, wherein at least one end of the control line is attached to the wall or ceiling of the animal confinement house through a large spring.

15. The system of claim 8, wherein the cylinder is capable of providing substantially continuous feedback to the controller regarding the position of the piston rod.
Figure 1

Poultry House with Properly Adjusted Vent Doors

Poultry House with Vent Doors Opened Too Wide