The invention is an inflatable bladder assembly for use in HVAC zone control systems. The bladder has a nozzle for inflating and deflating the bladder. The nozzle connects to a small air tube that is connected to the control system that provides pressure and vacuum for inflating and deflating the bladder. The bladder has at least two mounting tabs for attaching the bladder to a mounting fixture. A restraint fixture is attached to the mounting fixture. The restraint fixture firmly grips the nozzle and air tube. The restraint fixture allows the nozzle and air tube to be easily inserted into the fixture such that an airtight seal is made between the nozzle and air tube. The restraint fixture strongly resists forces that would remove the nozzle or air tube from the restraint fixture. The mounting fixture is attached to the duct system.
VENT-BLOCKING INFLATABLE BLADDER ASSEMBLY FOR A HVAC ZONE CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Technical Field of the Invention

This invention relates generally to dampers for controlling, closing and opening air circulation vents in an HVAC system, and more specifically to an inflatable bladder for insertion inside a vent or a duct.

2. Background Art

Most zone control systems for HVAC systems use electromechanical dampers to selectively control the airflow through portion of the trunk and duct system. Installation of these zone systems requires access to the ducts at multiple locations so that the dampers can be installed. This makes it difficult and expensive to install in existing systems since duct access is restricted, and it is difficult to run control wires form the electromechanical dampers to zone controller.

3. Prior Art

U.S. Pat. No. 5,348,078 issued Sep. 30, 1994 and U.S. Pat. No. 5,449,319 issued Sep. 12, 1995 to Dushane et al. describe a retrofit room-by-room zone control system for residential forced air HVAC systems that use complex electrically activated airflow control devices at each air vent. The devices are mechanically complex, each with a radio receiver, servo motor, and multiple mechanical levers. The devices are powered by batteries that are recharged by a generator powered by airflow through the air vent. Another embodiment is described that uses wires connected to a central control unit to control the airflow control devices, adding complexity to the installation process. The airflow control devices replace the existing air grills, so the installation is visible, and multiple sizes and shapes of airflow control devices are needed to accommodate the variety of air vents found in houses. The devices are expensive and have no shared mechanisms for control or activation to reduce the cost of the multiple devices required. The preferred embodiment uses household power wiring for communications between the thermostats and the central control, requiring visible wires from a power outlet to the thermostat.

4. Description

U.S. Pat. No. 4,545,524 issued Oct. 8, 1985, U.S. Pat. No. 4,600,144 issued Jul. 15, 1986, U.S. Pat. No. 4,742,956 issued May 10, 1988, and U.S. Pat. No. 5,170,986 issued Dec. 15, 1992 to Zeler, et al. describe a variety of inflatable bladders used as airflow control devices in air ducts. All of these are adapted for mounting in a way that requires access to the air ducts for cutting holes and inserting devices into the duct, and for the controlling the air tube to pass from the inside of the air duct to the outside of the duct for passage to the device that provides the air for the bladders. These airflow control devices do not provide a way for non-intrusive installation. In addition these bladders are held in place primarily by their inflation nozzle so the stress of holding the bladder in place against airflow pressure is transferred through the nozzle, creating a focused stress area which increases the demand on the bladder material and reduces service life.

The bladder disclosed in U.S. Pat. No. 5,170,986 issued Dec. 15, 1992 to Zeler, et al. includes a tab retaining means that is attached by means of a hole in the duct. This tab is a separate part bonded to the bladder and not integral to the pieces used to make the bladder. Using the tab requires access to the duct so the hole can be made and the tab placed in the hole.

U.S. Pat. No. 7,302,959 issued Dec. 4, 2007 to Gonia describes an inflatable bladder for airflow control that has a collocated air pump, valve, and wireless control for inflating and deflating the bladder. The bladder is installed through a hole cut in the duct. Batteries are used to power the pump and wireless control system. The batteries must be replaced periodically. Therefore access to the exterior of the duct is required for both installation and on-going maintenance.

U.S. Pat. No. 4,522,116 issued Jun. 11, 1985, U.S. Pat. No. 4,662,269 issued May 5, 1987, U.S. Pat. No. 4,783,045 issued Nov. 8, 1988, and U.S. Pat. No. 5,016,856 issued May 21, 1991 to Tartaglino describe a series of inflatable bladders of different shapes and control methods. The described control methods relate to the air pressure and vacuum used to inflate and deflate the bladders. The bladder shapes and mounting techniques are novel but different from those used in the present invention, since the bladders are comprised of two different materials with different physical properties. In addition, the air tube is connected to the bladder nozzle without a restraint mechanism to prevent stress on the nozzle and the interface between the air tube and the nozzle.

U.S. Pat. No. 5,234,374 issued Aug. 10, 1993 to Hzyk, et al. describes an inflatable bladder used as an airflow control device installed inside an air duct at an air vent. The bladder is inflated by a small blower also mounted in the air vent and powered by a battery. It receives control signals from a separate thermostat located in the room. This device uses substantial power and battery life is limited. Since the blower for inflating the bladder is located at the air vent, noise from the blower is a problem which the inventor provides a muffler to help control. Each bladder is an independent unit and there is no sharing of components for controlling or powering, so there are no savings when many airflow devices are used in a zone control system. The device does provide a practical solution for providing centrally controllable airflow devices for each air vent in a house. U.S. Pat. No. 6,786,473 issued Sep. 7, 2004 to Alls, U.S. Pat. No. 6,893,889 issued Nov. 1, 2004 to Alls, U.S. Pat. No. 6,997,390 issued Feb. 14, 2006 to Alls, U.S. Pat. No. 7,062,830 issued Jun. 20, 2006 to Alls, U.S. Pat. No. 7,162,884 issued Jan. 16, 2007 to Alls, U.S. Pat. No. 7,188,779 issued Mar. 13, 2007 to Alls, and U.S. Pat. No. 7,392,661 issued Jul. 1, 2008 to Alls, describes various aspects of a HVAC zone climate control system that uses inflatable bladders. The present invention is by the same inventor and is designed to work with this system. This system has multiple inflatable bladders installed in the supply ducts such that the airflow to each vent can be separately controlled by inflating or deflating the bladder in its supply duct. Each bladder is connected to an air tube that is routed through the duct and trunk system back to a set of computer controlled air valves that can separately inflate or deflate each bladder. Based on temperature readings from each room and the desired temperatures set for each room, the system controls the heating, cooling, and circulation equipment and inflates or deflates the bladders so that the conditioned air is directed where needed to maintain the set temperatures in each room.

U.S. Pat. No. 7,207,496 issued Apr. 24, 2007 to Alls describes an inflatable bladder for use in this system in which a pin is used to couple the air tube to the bladder. This bladder requires several operations to connect the air tube to the bladder and to attach the air tube to the mounting strap. Each operation requires some training and experience to
become proficient. Each operation takes some time to perform. Each operation provides an opportunity to make an error that requires extra time to correct or may require a service call to repair. These operations require several tools that must be carried from room-to-room. System installation requires installing a bladder for every vent, so each operation is repeated multiple times. The disclosed bladder is only constrained by its nozzle and its connection to the air tube, so the bladder can assume different orientations as it is inflated. This lack of constraint places unnecessary limits on the bladder shapes that can be used. All of the stress of holding the bladder in place is transferred though the nozzle to the air tube, creating a focused area of stress which decrease reliability and the service life of the bladder.

OBJECTS OF THIS INVENTION

[0012] An object of this invention is to simplify the installation of inflatable bladders used in HVAC zone systems.  

[0013] Another object of this invention is to reduce the installation time of inflatable bladders used in HVAC zone systems.  

[0014] Another object of this invention is to improve the quality and reliability of installation of inflatable bladders used in HVAC zone systems.  

[0015] Another object of this invention is to enable the use of bladder shapes that reduce the volume of air needed to inflate and deflate.

SUMMARY

[0016] The invention is an inflatable bladder assembly for use in HVAC zone control systems. The bladder has a nozzle for inflating and deflating the bladder. The nozzle connects to a small air tube that is connected to the control system that provides pressure and vacuum for inflating and deflating the bladder. The bladder has at least two mounting tabs for attaching the bladder to a mounting fixture. A restraint fixture is attached to the mounting fixture. The restraint fixture firmly grips the nozzle and air tube. The restraint fixture allows the nozzle and air tube to be easily inserted into the fixture such that an airtight seal is made between the nozzle and air tube. The restraint fixture strongly resists forces that would remove the nozzle or air tube from the restraint fixture. The mounting fixture is attached to the duct system.

[0017] No tools are required to attach the bladder assembly to the air tube. The air tube is inserted by hand force into the restraint fixture and nozzle. The air tube can not be removed from the assembly by the stresses that occur during installation and operation. This air tube attachment method is easier, faster, and more reliable than prior art. The bladder is securely attached to the mounting fixture so that its orientation is fixed as it is inflated and deflated. This ensures complete sealing or the duct with bladder shapes that use a smaller volume of air for inflation and deflation than prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention will be understood more fully from the detailed description given below and from the accompanying drawings of embodiments of the invention which, however, should not be taken to limit the invention to the specific embodiments described, but are for explanation and understanding only.

[0019] FIG. 1A shows a perspective view of a typical complete cylindrical bladder assembly.

[0020] FIG. 1B is a cut away perspective view showing a typical complete cylindrical bladder assembly installed in a typical duct.

[0021] FIG. 2A shows the fabric pieces that are assembled to make a cylindrical bladder.

[0022] FIG. 2B is a perspective view the bladder nozzle.

[0023] FIG. 2C is a cross-section view of the bladder nozzle.

[0024] FIG. 2D is a perspective view of an inflated cylindrical bladder.

[0025] FIG. 3A shows the fabric pieces that are assembled to make a truncated cylindrical bladder.

[0026] FIG. 3B is a perspective view of an inflated truncated cylindrical bladder.

[0027] FIG. 4A shows the fabric pieces that are assembled to make a rectangular bladder.

[0028] FIG. 4B is a perspective view of an inflated rectangular bladder.

[0029] FIG. 4C is a perspective view of a typical complete rectangular bladder assembly.

[0030] FIG. 5A is a perspective view of a vent cut directly into a supply trunk.

[0031] FIG. 5B is a perspective view of a mounting fixture with restraint fixture for a vent cut directly into a supply trunk.

[0032] FIG. 5C is a perspective view of an inflated rectangular bladder for use in a mounting fixture for a vent cut directly into a supply trunk.

[0033] FIG. 5D is a perspective view of a complete bladder assembly for use with a vent cut directly into a supply trunk.

[0034] FIG. 5E is a perspective view of the rubber bladder assembly installed in a vent cut directly into a supply trunk.

[0035] FIG. 6A shows the outline of the restraint fixture before forming.

[0036] FIG. 6B shows a perspective view of the restraint fixture after forming.

[0037] FIG. 6C is a cross-section view of a nozzle and air tube in the restraint fixture.

[0038] FIG. 7A shows an exploded side-view of attaching a bladder and restraint fixture to a mounting strap using rivets.

[0039] FIG. 7B shows an exploded perspective view of attaching a bladder and restraint fixture to a mounting strap using integrated metal tabs.

DETAILED DESCRIPTION

[0040] FIG. 1A shows a typical complete cylindrical bladder assembly 10 as prepared in a factory and supplied for use by an installer of the zone control system. The bladder 20 is made of flexible airtight fabric material. Its shape when inflated is a cylinder. The bladder has a nozzle 21 used to inflate or deflate the bladder. The nozzle is inserted into restraint fixture 60 through hole 610 which firmly grips the outside surface of the nozzle. Each end of the bladder is firmly attached to mounting strap 11. In the preferred embodiment, the strap is typically 1" wide and 36" long and made from 20 gauge (approximately 0.035" thick) mild steel. This should not be taken to limit the scope of the invention since many other materials and dimensions can provide similar function. The requirements are the strap is flexible in one direction perpendicular to its long axis so the strap can easily follow bends in the duct system. The strap is rigid in the direction perpendicular to flexible direction and rigid in the direction of the long axis so that the position of the bladder is fixed.

[0041] Since both ends of the bladder are attached to the strap, the location and orientation of the bladder relative to the
mounting strap is fixed as the bladder is inflated or deflated. The mounting strap has two mounting holes 110 and 111 located at the end opposite the bladder. The holes are sized to accommodate typical sheet metal screws used in the HVAC industry. The restraint fixture is attached to the opposite end of the mounting strap such that the nozzle is restrained in approximately the position it would naturally assume when the bladder was inflated. The nozzle location is fixed relative to the mounting strap by the restraint fixture.

Fig. 1B is a cut away perspective diagram showing the bladder assembly 10 of Fig. 1A after it is installed in duct 122. The duct is connected to boot 121 adapted for installation in a floor in this example. The boot forms vent 120 which admits conditioned air to the room. The vent is normally covered by a grill (not shown) which prevents objects from falling into the boot and duct. End 124 of the duct is connected to other ducts and trunks that connect to the central HVAC equipment that supplies the conditioned air. Air tube 123 is inserted into restraint fixture 60 and pushed as far as possible into nozzle 21. The restraint fixture firmly grips the outside surface of the air tube. An interference fit between the inside of the nozzle and the outside of the air tube makes a substantially air tight seal. The restraint fixture securely holds the air tube and is therefore indirectly secured to the mounting strap 11. The mounting strap is typically fastened to the boot using sheet metal screws 124 and 125 that pass through holes 110 and 111 shown in Fig. 1A, thereby fixing the location and orientation of bladder 20 inside the duct. The air tube is securely held by the restraint fixture so that there is essentially no stress or force on the interface between the air tube and the nozzle. The restraint fixture securely maintains the location of the nozzle relative to the air tube as the bladder inflates and deflates and if the air tube is pulled or pushed.

The bladder is shown fully inflated such that there is negligible space between the bladder and interior of the duct, thereby effectively sealing the duct and blocking airflow. Typically the bladder is inflated to a pressure between 0.5 psi and 1 psi. This is sufficient to create a tight seal and well below the pressure rating of the duct. Typically the bladder is deflated using a negative pressure between ~0.5 psi and ~1 psi. This causes the bladder to completely collapse. When deflated the bladder is firmly held to the mounting strap and presents negligible resistance to airflow through the duct.

U.S. Pat. No. 7,062,830 issued Jun. 20, 2006 to Alles discloses a process for installing air tubes in the ducts of a typical residential HVAC system. When using this process, the air tube 123 is threaded through the duct system from the central HVAC equipment through duct 122 and boot 121 and vent 120 into the room. The bladder assembly 10 can be installed anytime after the air tube is installed. The installer selects the appropriate sized bladder assembly for the duct. The installer pulls the air tube 123 gently to remove slack and cuts the air tube a few inches beyond the vent. The installer squeezes the bladder to deflate it and inserts the air tube as far as possible through the restraint fixture and into the bladder nozzle. The installer then slides the bladder assembly through the boot into the duct until the end of the mounting strap 11 is inside the boot. The installer can bend the mounting strap such that it matches the path through elbows and bends typically found in ducts. After checking the position of the bladder and mounting strap, the installer attaches the strap to the boot using sheet metal screws 124 and 125.

The bladder should be installed such that it inflates against a smooth section of the duct. It should not be installed such that it inflates against sharp seams or screws which are common in some duct systems. If the length of the mounting strap is not appropriate to position the bladder, the installer may cut the strap to make it shorter, or attach a length of similar material to make the strap longer. HVAC installers typically have the tools and material to accomplish this task.

From the described installation process using the described bladder assembly, it is clear this invention eliminates several tools and operations required by the prior art. The bladder is connected to the air tube and the air tube is firmly attached to the mounting strap by simple hand insertion that requires no tools or other supplies. After the bladder assembly is inserted into the duct, the strap is attached using sheet metal screws. HVAC installers are proficient at using sheet metal screws. The installer requires very little training or experience to become proficient at installing the bladders. Each installation step is simple and can be performed quickly. Therefore bladder installations can be done quickly with little effort. The small number of operations means there are few opportunities to make mistakes. The nozzle and air tube are securely joined and the bladder is securely positioned and oriented ensuring long trouble free operation.

Fig. 2A shows the shapes of the pieces used to make cylindrical bladder 20 shown in Fig. 1A. The material can be fabric, plastic film, or a laminate of fabric and plastic film. The material used in the preferred embodiment is a laminate of woven or knit fabric made of nylon or polyester and a film of urethane approximately 0.003" thick. The total thickness of the laminate is approximately 0.010". The fabric layer provides flexible strength. The urethane film layer provides an airtight barrier. The two layers are tightly bonded together. An airtight seam is formed between two pieces of the laminate by placing the urethane surfaces together and applying heat and pressure. In the preferred manufacturing process, the heat is generated using RF energy. Other seam making methods could be used such as sewing or adhesives.

In Fig. 2A, rectangular piece 22 is used to form the walls of the cylindrical bladder. Circular shaped pieces 23 and 24 are used to form the ends of the cylinder. The dashed lines show where seams are formed. The circles formed by seam lines 203 and 205 have a diameter slightly larger than the inside diameter of the duct that will be sealed by the bladder. For example, if the preferred embodiment of a bladder to control a duct with 8" inside diameter has circles 203 and 205 with diameters of approximately 8.5". The seams formed by the RF heating process are approximately 1/4 wide. Annular 3/4 of extra fabric is provided outside the seam. For this example, the diameters of 23 and 24 are approximately 9". In general, the diameter is approximately 1° greater than the diameter of the duct. The tabs 206 and 207 extending from the circumferences of 23 and 24 are used to attach the bladder to the mounting strap 11 shown in Fig. 1. Each tab is approximately 1° by 1°. Tab 207 has two holes 208 for attaching to the mounting strap. Tab 206 has four holes 209 for attaching to the mounting strap. Cylinder end piece 23 has hole 26 for passing the nozzle through the bladder.

In Fig. 2A, the length of the seam line 202 and 204 is equal the circumference of circles 203 and 205. The length of seams 200 and 201 are typically 50% to 100% of the diameter of the duct. Bladders for smaller ducts (4°-6°) typically have lengths about equal to their diameter. Bladders for larger ducts (8"-12") typically have lengths about 1/2 their diameter.
FIG. 2B is a perspective drawing of the nozzle 21 used in bladder 20 shown in FIG. 1A. The air tube is inserted in the narrow end 210 and the wide end 211 is attached to the bladder. In the preferred embodiment the nozzle is approximately 1" long and 1" in diameter at the wide end 211. The nozzle is molded of urethane which facilitates using RF heating to bond the nozzle to the urethane film of the laminate material. The urethane is formulated to be sufficiently flexible to slightly expand as the air tube is inserted and to accommodate normal irregularities in the shape of the air tube. The urethane is sufficiently rigid to prevent excessive bending or crimping as the air tube is inserted.

FIG. 2C is a cross-section drawing of the nozzle through its central axis. The nozzle inside 210 is sized and shaped so that a substantially airtight seal is made when the air tube is inserted. The inside diameter 210 of the nozzle at the insertion end is slightly larger than the diameter of the air tube. The inside diameter tapers to smaller diameter 212, then abruptly changes to diameter 213 which is approximately the same as the inside diameter of the air tube. The urethane flexibility and taper of the nozzle allows the air tube to be inserted using hand force to form an air tight seal. In the preferred embodiment, the air tube does not need to reach the abrupt reduction to diameter 213 to form an air tight seal.

FIG. 2D is a perspective view of an assembled cylindrical bladder that is inflated. The urethane side of the laminate is inside the bladder and the seams are formed by bonding urethane to urethane. The assembly process first bonds the nozzle 21 to side 23. The narrow end of the nozzle is passed through hole 26 in FIG. 2A from the urethane side of 23 and the urethane side of the laminate is bonded to side 211 shown in FIG. 2B of the nozzle. Then an open cylinder is constructed by bonding seam 200 to seam 201 shown in FIG. 2A of piece 22. Then one end of the cylinder is closed by bonding seam 202 and seam 203 shown in FIG. 2A. The seam 200 and 201 is oriented to be opposite the tab extension 206 on end 23. The other end of the cylinder is closed by bonding seam 204 and 205 shown in FIG. 2A. The seam 200 and 201 is oriented to be opposite the tab extension 207 on end 24. The excess fabric 220 between the seams and the edges of the three pieces are all outside the bladder.

FIG. 3A shows the shapes of the fabric pieces used to make a bladder in the shape of a cylinder truncated by a plane surface. Truncating the cylinder substantially reduces the volume of air needed to inflate and deflate the bladder. For larger bladders, using a truncated shape significantly reduces the time needed to inflate and deflate the bladder compared to a cylindrical bladder. The truncated cylinder in FIG. 3A is derived from the bladder shown in FIG. 2D by fixing the location of tab 207 while tilting the end opposite end 23 toward end 23 until seam 200 an 201 shown in FIG. 2A is approximately 2" long. This transforms the circular end 24 and seam 205 in FIG. 2A into ellipse 30 and seam 300 shown in FIG. 3A. Ellipse 30 has mounting tab 310 and holes 311 for attaching the assembled bladder to the mounting strap. Straight seam 204 on piece 22 shown in FIG. 2A is transformed into curved seam 301 on piece 31 which has the shape of a sine wave function. The length of seam 301 is equal to the circumference of seam 300. Seams 302 and 303 are approximately 2" long. Piece 23 is unchanged by this process, so piece 32 is the same shape as piece 23. Hole 306 is used for passing nozzle through end 32. Tab 312 and holes 313 are used for attaching the bladder to the mounting strap. The length of seam 304 is equal to the circumference of seam 305. The parameters for the seam width, excess fabric between the seams and the edges of the pieces, and the extension tabs are the same as the cylindrical bladder described in the foregoing.

FIG. 3B is a perspective view of an assembled truncated cylindrical bladder that is inflated. Elliptical end 30 is sealed to piece 31 and piece 31 is sealed to piece 32. Tabs 310 and 312 are used to attach the bladder to a mounting strap. Nozzle 21 is used to inflate and deflate the bladder.

FIG. 4A shows the shapes of the fabric pieces used to make a bladder in the shape of a rectangular prism. These shapes are used to seal square or rectangular ducts. In residential HVAC systems, the rectangular ducts serving individual vents are typically 3/4" high so that they can fit in walls constructed using 2x4 framing. These ducts are typically 10", 12", or 14" wide. In the preferred embodiment, the pieces 40, 41 and 42 are sized so that the assembled and inflated bladder is approximately ¾ larger than the dimensions of the duct. The depth of the bladder is approximately equal to the height of the duct. As an example, consider a bladder for a 3/4" by 10" duct. The seams 411, 412, 418, and 421 are 3/16" long. Seams 410, 413, 419, and 420 are 10 3/16 long. Seams 415 and 416 are 3/16". Seams 414 and 417 are equal to the sum of the length of seams 410, 411, 412, and 413 which in this example is 27 7/8". The seam widths and the extra fabric between the seams and edges is the same as for the cylindrical bladder described in the foregoing.

FIG. 4B has tab 422 with holes 423 for attaching the bladder to the mounting strap. Piece 42 has hole 424 or passing the nozzle through the bladders. Tab 427 with hole 426, tab 428 with holes 429, and tab 430 with hole 425 are used to attach the bladder to the mounting strap.

The rectangular prism is assembled by passing a nozzle 21 of the type shown in FIG. 2B through hole 424 and bonding it to the urethane surface of piece 42. Four sides of the prism are formed by bonding seams 415 and 416 of piece 41. The nozzle side of the prism is closed by bonding seams 418, 419, 420, and 421 to seam 417 while positioning the center of tab 428 at the midpoint of seam 417. The opposite side of the prism is closed by bonding seams 410, 411, 412, and 413 to seam 414 while positioning the center of tab 422 at the mid point of seam 414.

FIG. 4C is a perspective view of an assembled rectangular prism bladder that is inflated. Side 42 is visible with nozzle 21. The tabs 426, 428, and 430 on side 42 are visible where they extend beyond the extra fabric of side 41. The extra fabric associated with seams 415 and 416 is visible at the top. Tab 422 on side 40 is visible beyond the extra fabric of side 41.

FIG. 4D is a perspective view of a rectangular prism bladder of FIG. 4B attached to mounting strap 450 using tabs 422 and tab 428 shown in FIG. 4B. These tabs cannot be seen in this FIG. 4C. Restraint fixture 60 is attached to the end of strap 450 and nozzle 21 is inserted in to the restraint fixture. A second mounting strap 451 is attached to strap 450. It is centered and at a right angle relative to strap 450. The edge
of strap 451 is located under the center of restraint fixture 60. Strap 451 is approximately 1" shorter than the width of the bladder. Tabs 426 and 430 of side 42 are attached to strap 451 using holes 425 and 426 (FIG. 4A). These four attachments ensure the rectangular bladder remains in the proper location and orientation so that when inflated it completely blocks airflow in the duct.

FIG. 5A shows a perspective view of supply vent 500 cut directly into a section of large residential HVAC supply trunk 501. Only a short portion of the trunk is shown. The supply airflow is from end 502 toward end 503. This vent type is typically used to supply conditioned air to basement rooms. A portion of the airflow in the trunk will flow through the vent, but a majority of the airflow passes by the vent to other areas of the home. Typically vent edges 511 and 513 are 4" to 6" high and vents edges 510 and 512 are 8" to 14" wide. The vent is covered by a grill that is not shown. FIG. 5B is a perspective view of bladder mounting fixture 520 used to control airflow through the vent 500 shown in FIG. 5A. The preferred embodiment is made from the 26 gauge sheet metal typically used to fabricate HVAC ducts. It is cut from a flat sheet, bent to shape, and seamed using standard HVAC fabrication processes. Surfaces 521, 522, 523, and 524 form the sides of a short rectangular duct. The height of the duct formed by sides 521 and 523 is slightly less than the height of the vent edges 511 and 513 shown in FIG. 5A. The depth of the duct formed by sides 522 and 524 is typically 3" to 5" depending on the required airflow. Restraint fixture 60 is attached to side 521 of the mounting fixture centered on edge 530. Tabs 526, 527, and 528 are used to attach the mounting fixture to trunk 501 shown in FIG. 5A. Tabs 526 and 528 are slightly shorter than edges 510 and 512 of vent 500 shown in FIG. 5A. The widths of tabs 526 and 528 are such that distance between their outside edges is at least ¼ more than the height of vent edges 511 and 513 shown in FIG. 5A. The distance between the inside edge of tab 527 and edge 529 is less than the width of the vent edges 510 and 512 shown in FIG. 5A. The distance between the outside edge of tab 527 and edge 529 is at least ¼ more than the width of the vent edges 510 and 512 shown in FIG. 5A.

FIG. 5C shows a perspective view of a rectangular prism bladder 540 sized to seal the short rectangular duct formed by mounting fixture 520 shown in FIG. 5B. This bladder is constructed as described for the rectangular bladder described in the foregoing. Side 541 has nozzle 21 (FIG. 2). The bladder has mounting tabs 543, 544, 545, and 546.

FIG. 5D is a perspective view the complete bladder assembly. The bladder nozzle 21 is inserted into restraint fixture 60 and the tabs 543 and 545 are attached to the mounting fixture side 521. The bladder mounting tabs 544 and 546 shown in FIG. 5C are also attached to the mounting fixture side 521. These tabs are hidden in this view.

FIG. 5E shows the outside of trunk 501 with the assembled bladder properly positioned to control vent 500. The assembled bladder is installed by threading the air tube through vent 500 and inserting the air tube into the restraint fixture 60 shown in FIG. 5D. The bladder assembly is then inserted into the trunk 501 through vent 500. The bladder assembly is positioned so that tab 527 meets edge 511 shown in FIG. 5A, tab 528 meets edge 510 shown in FIG. 5A, and tab 526 meets edge 512 shown in FIG. 5A. The tabs 526, 527, and 528 are outside the trunk. All other parts of the bladder assembly are inside the trunk. Six sheet metal screws 561 are used to attach the three mounting tabs to the supply trunk. Two sheet metal screws 560 are used to attach the trunk surface near vent edge 513 to surface 521 of the mounting fixture shown in FIG. 5B. The installer may use sealing tape or mastic to make all seams airtight between the trunk and the assembled bladder. After installation, the only path for airflow through vent 500 is through the short duct of the mounting fixture 520 shown in FIG. 5B. Therefore airflow through the vent is fully controlled by inflating and deflating bladder 540 shown in FIG. 5C.

FIG. 6A shows the outline of the metal piece used to form the preferred embodiment of the restraint fixture 60. In the preferred embodiment, the outline shape of 60 is punched from 28 gauge sheet metal or similar material. The spoke-wheel shaped hole 61 forms the restraint for the bladder nozzle. The hub 610 of the wheel has a diameter about 10% smaller than the diameter of the nozzle at its assembled location in the restraint fixture. The eight spokes of the wheel divide the hub into eight sections, forming eight edges that grip and securely hold the nozzle. Edge 611 is one of the eight edges. The spokes also forms eight trapezoidal shapes that provide a separate spring action for each edge. The eight dashed lines around the perimeter of the wheel are bend lines of approximately 15 degrees down into the plane of the drawing. Bend line 612 is one of the eight bend lines. As the bend angle increases, the effective diameter of the hub increases. When properly bent, the hub diameter is slightly larger than the initial diameter of the nozzle. As the nozzle is inserted, its tapered diameter forces the edges 611 to move so as to accommodate the larger diameter.

The spoke-wheel shaped hole 62 forms the restraint for the air tube. The hub 620 of the wheel has a diameter about 10% smaller than the outside diameter of the air tube. The eight spokes of the wheel divide the hub into eight sections, forming eight edges that grip and securely hold the air tube. The spokes also form eight trapezoidal shapes that provide a separate spring action for each edge. Edge 621 is one of the eight edges. The eight dashed lines around the perimeter of the wheel are bend lines of approximately 15 degrees down into the plane of the drawing. Bend line 622 is one of the eight bend lines. As the bend angle increases, the effective diameter of the hub increases. When properly bent, the hub diameter is slightly smaller than the outside diameter of the air tube. Dashed lines 63, 64, 65, and 66 are 90 degree bend lines down into the plane of the drawing. Holes 670, 671, 672, and 673 are used to attach the restraint fixture to the mounting strap.

FIG. 6B is a perspective view of the fully formed restraint fixture. The bend lines 63, 64, 65, and 66 shown in FIG. 6A form the edges 63, 64, 65, and 66 of the rectangular shape shown in FIG. 6B. The holes 670, 671, and 673 are used for rivets or other fasteners to attach the restraint fixture to the mounting strap 11 shown in FIG. 1A or mounting fixture 520 shown in FIG. 5B. Hole 673 shown in FIG. 6A is not visible in FIG. 6B. After attachment, the restraint fixture is rigid and retains its shape as the nozzle or air tube is pushed or pulled.

FIG. 6C is a cross-section view of the restraint fixture with a nozzle 21 and air tube 123 inserted. For small displacements of the edges 611 and 621, the spring action is linear so displacement increases with force. An edge will...
return to its original locations when the force is removed. If the displacement exceeds the elasticity of the metal, the bend angle associated with the edge will increase and permanently change the location of the edge. The spring action is then around the new permanent location of the edge. The eight edges 611 together can adjust to the diameter of the nozzle while each edge applies pressure to the outside surface of the nozzle. The eight edges 621 together can adjust to the diameter of the air tube while each edge applies pressure to the outside surface of the air tube.

[0071] As the nozzle is inserted into the restraint fixture, the hub diameter 610 shown in FIG. 6A increases to accommodate the taper of the nozzle. The bend angle can increase to accommodate large changes while maintaining the spring action for the new location of the edges. The properties of the metal are such that hand force can bend the eight segments as the nozzle is inserted during assembly. After the nozzle is inserted, each edge presses firmly into the elastic material of the nozzle.

[0072] If a force is applied to remove the nozzle, the edges dig into the nozzle material and are displaced so as to decrease the diameter of the hub. This increases the force each edge 611 applies to the nozzle, increasing the grip of the restraint fixture on the nozzle. As the air tube is inserted, the hub diameter 620 shown in FIG. 6A increases to accommodate the air tube. If pressure is applied to remove the air tube, each edge 621 increases their grip on the air tube, firmly restraining the air tube. The restraint fixture allows the nozzle and air tube to be easily inserted, but strongly resists forces to remove the nozzle or air tube.

[0073] A similar restraint fixture could be made using molded plastic. Other arrangements of gripping edges that provide easy insertion and difficult removal could also be used. The detailed description of the preferred embodiment should not be interpreted as limitation of the scope of the restraint fixture for this invention.

[0074] FIG. 7A is an exploded side view of an assembly of a bladder 70, restraint fixture 60, and mounting strap 11. The bladder nozzle 21 is inserted into the restraint fixture and bladder tab 79 is positioned between the restraint fixture and the mounting strap. Rivets 74 and 75 are two instances of four rivets that pass through the mounting fixture, the bladder tab, and the mounting strap. The bottoms of the rivets are expanded to hold them in place. When conventional rivets are used, matching holes are made in the restraint fixture, bladder tab, and mounting strap. When self-piercing rivets are used, these holes are not necessary. The force of the rivet setting tool causes the rivet to pierce the restraint fixture and bladder tab and firmly imbed in the mounting strap. A strain relief plate 76 is used to attach the second bladder tab 78 to the mounting strap. The plate is made of the same material as the restraint fixture and it is slightly smaller in size than the bladder tab. Rivet 77 is one instance of two rivets used that pass through the strain relief plate, the bladder mounting tab, and the mounting strap. When conventional rivets are used, matching holes are made in the restraint fixture, bladder tab, and mounting strap. When self-piercing rivets are used, these holes are not necessary.

[0075] FIG. 7B is an exploded perspective view of an alternative method of attaching the bladder and restraint fixture to the mounting strap. Six tombstone-shaped attaching tabs 720 through 725 are punched and bent up 90 degrees from the mounting strap 72. Slots 760 and 761 punched into strain relief plate 76 in locations that match attaching tabs 720 and 721. The holes in bladder tab 78 (not shown in FIG. 7B) match the locations of the two attaching tabs. The holes in the bladder are aligned with the attaching tabs and the bladder tab is placed in contact with mounting strap 72. The strain relief plate slots are aligned with the attaching tabs and the plate is pressed in to contact with the bladder tab and mounting strap. The attaching tabs are bent away from the center of the strap and flattened. The bent tabs securely attach the strain relief plate and bladder tab 78 to the mounting strap. In a similar fashion, four slots 710, 711, 712, and a hidden slot are positioned on the restraint fixture to match the locations of attaching tabs 722-724. The four holes in bladder mounting tab 79 (not shown in FIG. 7B) match the positions of the attaching tabs. The bladder tab 79 is positioned over the attaching tabs and pressed into contact with mounting strap 72. The restraint fixture slots are aligned with the attaching tabs and restraint fixture is pressed into contact with the mounting strap. The four attaching tabs are bent away from the center of the mounting strap and flattened. The bent tabs securely attach the restraint fixture and bladder tab to the mounting strap.

Conclusion

[0076] From the foregoing description, it will be apparent that there has been provided an improved bladder assembly for use with HVAC zone control systems. The installation of the bladder assembly of this invention has many advantages compared to the prior art. The installation process requires less training, fewer tools, takes less time, and produces a more consistent and reliable result. Variation and modification of the described system will undoubtedly suggest themselves to those skilled in the art. Accordingly, the foregoing description should be taken as illustrative and not in a limiting sense.

[0077] The various features illustrated in the figures may be combined in many ways, and should not be interpreted as though limited to the specific embodiments in which they were explained and shown. Those skilled in the art having the benefit of this disclosure will appreciate that many other variations from the foregoing description and drawings may be made within the scope of the present invention. Indeed, the invention is not limited to the details described above. Rather, it is the following claims including any amendments thereto that define the scope of the invention.

What is claimed is:

1. A pneumatic bladder assembly for use as an airflow control mechanism in an HVAC system, in which an air pump selectably provides one of pressure and vacuum to an air tube extending through ductwork of the HVAC system, said bladder assembly comprising:
   a) an inflatable and deflatable bladder having a plurality of means for attaching and a nozzle for coupling to said air tube,
   b) a restraint fixture for restraining the locations of said nozzle and said air tube in proper alignment for coupling,
   c) a mounting fixture for fixing the location of said bladder assembly in a duct of said HVAC system, said means for attaching attached to said mounting fixture and said restraint fixture attached to said mounting fixture such that it restrains said nozzle.

2. The bladder assembly of claim 1 where said restraint fixture allows easy insertion by hand force of said air tube into
said restraint fixture and said nozzle and said restraint fixture resists forces directed such as to remove said air tube from said restraint fixture.

3. The bladder assembly of claim 1, said restraint fixture comprising:
   a) a plurality of edges arranged to grip with spring action the outside of said air tube,
   b) a plurality of edges arranged to grip with spring action the outside of said nozzle,
   c) a means for positioning the air tube gripping edges and the nozzle gripping edges such that when said nozzle and said air tube are inserted into said restraint fixture, said nozzle and said air tube are in proper alignment for coupling.

4. The bladder assembly of claim 1, said bladder comprising a plurality of separate pieces cut from flexible material and joined using air-tight seams, and one of said separate pieces having a tab extending beyond said seams for attaching said bladder.

5. The bladder assembly of claim 1, said bladder comprising a plurality of separate pieces cut from flexible material and joined using air-tight seams, said separate pieces shaped such that said bladder approximates a cylindrical shape when inflated, and one of said separate pieces having a tab extending beyond said seams for attaching said bladder.

6. The bladder assembly of claim 1, said bladder comprising a plurality of separate pieces cut from flexible material and joined using air-tight seams, said separate pieces shaped such that said bladder approximates a truncated cylindrical shape when inflated, and one of said separate pieces having a tab extending beyond said seams for attaching said bladder.

7. The bladder assembly of claim 1, said bladder comprising a plurality of separate pieces cut from flexible material and joined using air-tight seams, said separate pieces shaped such that said bladder approximates a rectangular prism shape when inflated, and one of said separate pieces having a tab extending beyond said seams for attaching said bladder.

8. The bladder assembly of claim 1 where said mounting fixture is a strap that is flexible in one direction perpendicular to the long axis of said strap and is rigid in other directions perpendicular to the flexible direction.

9. The bladder assembly of claim 1, said mounting fixture comprising a structure that fits through a vent cut into a trunk of said HVAC system, said structure incorporating a short section of duct and other partitions such that when said mounting fixture is installed in said vent and said trunk, all airflow from said trunk through said vent must pass through said short section of duct.

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