US 20120270493A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2012/0270493 A1**

(43) **Pub. Date: Oct. 25, 2012**

Oliver et al.

(54) **PACKLESS SILENCER FOR A VENTURI CONTROL VALVE**

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(21) Appl. No.: **13/403,486**

(22) Filed: **Feb. 23, 2012**

Related U.S. Application Data

(60) Provisional application No. 61/477,858, filed on Apr. 21, 2011.

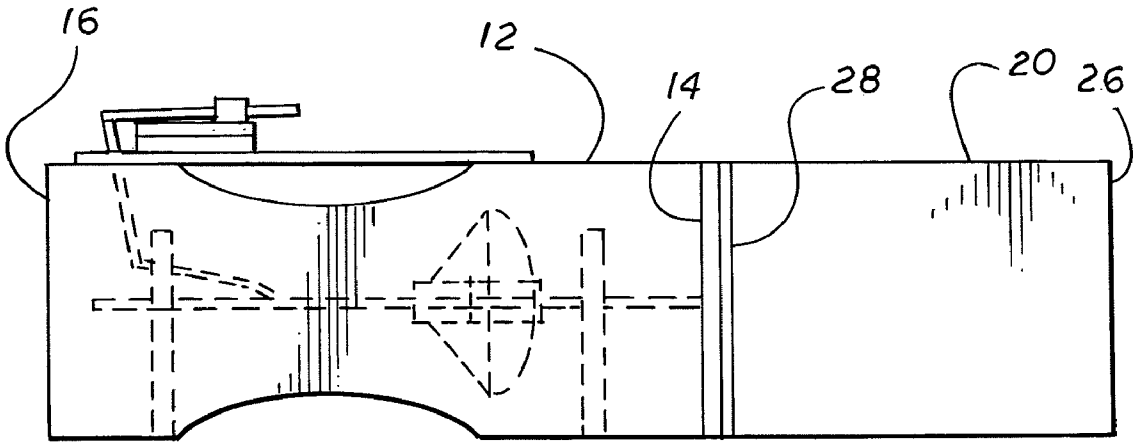
Publication Classification

(51) **Int. Cl.**
F24F 11/04 (2006.01)
E04F 17/04 (2006.01)

(52) **U.S. Cl.** **454/229**; 181/224; 454/906; 454/236

(57) **ABSTRACT**

A packless silencer for a Venturi control valve being a generally rectangular enclosed housing formed by four side walls and having an intake opening and a discharge opening. Four perforated baffles for each of the side walls are positioned inside of the housing, extend the length of the housing and are offset from the side walls to create an empty baffle space between the perforated baffles and the side walls the ends of the baffle space are covered by end caps.



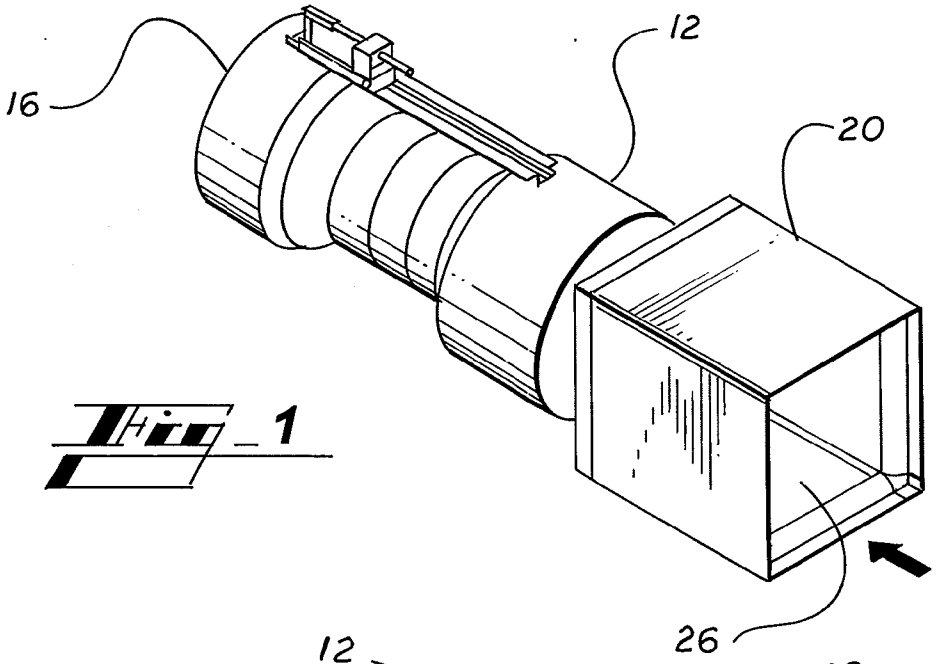


Fig_1

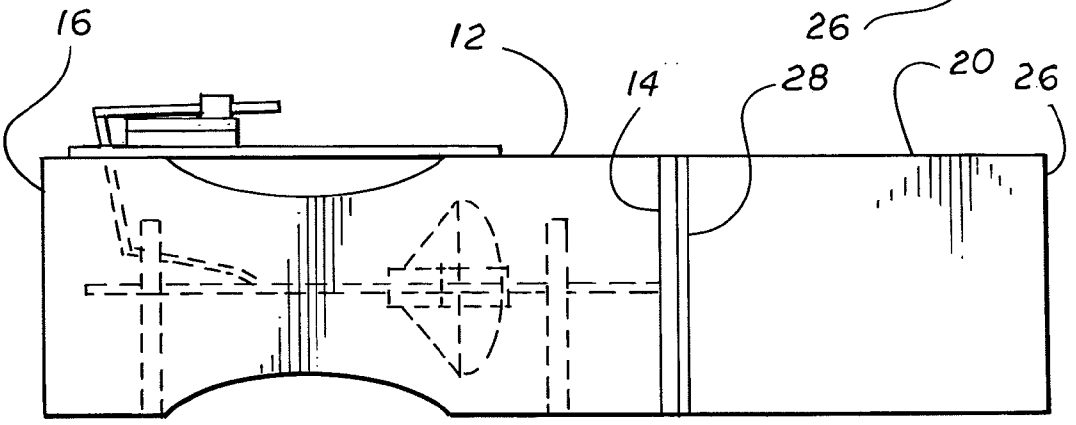


Fig_2

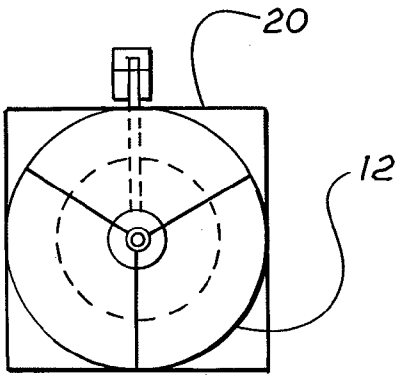


Fig_3

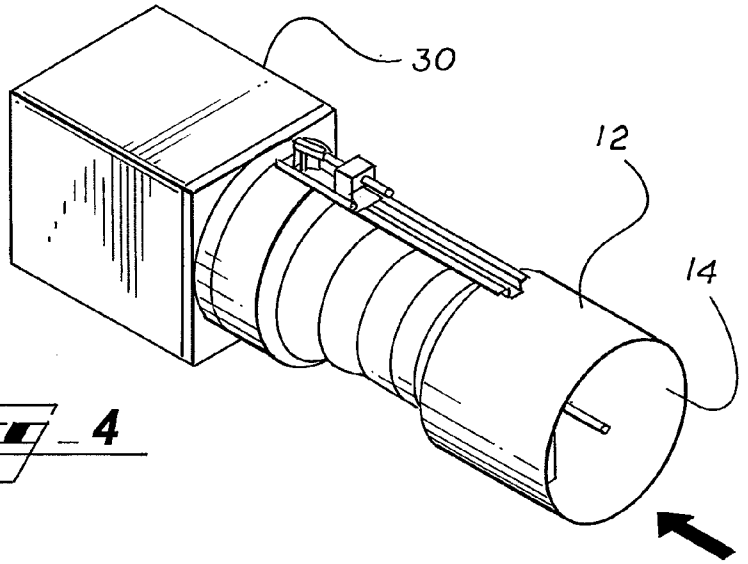


Fig. 4

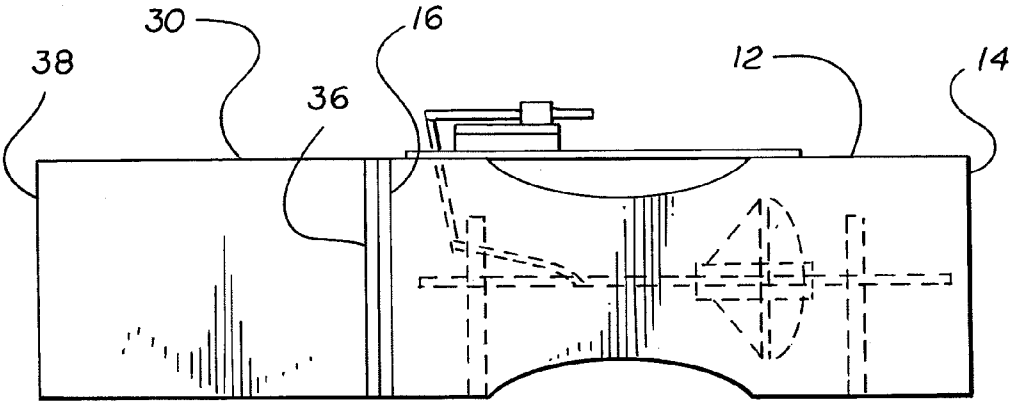


Fig. 5

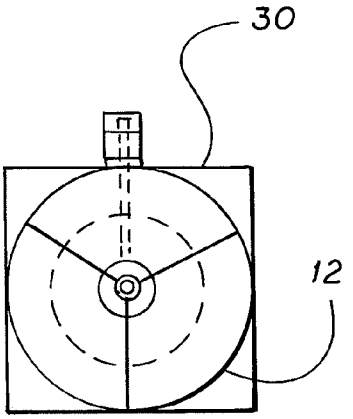
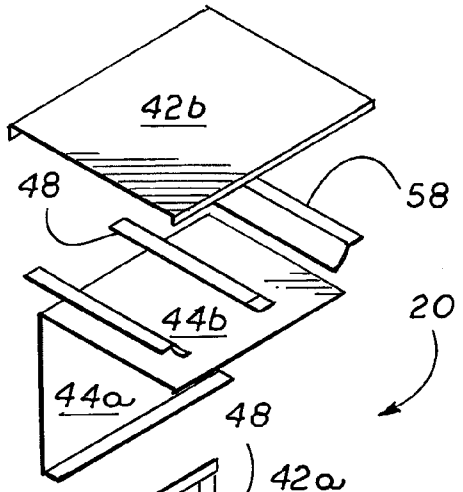
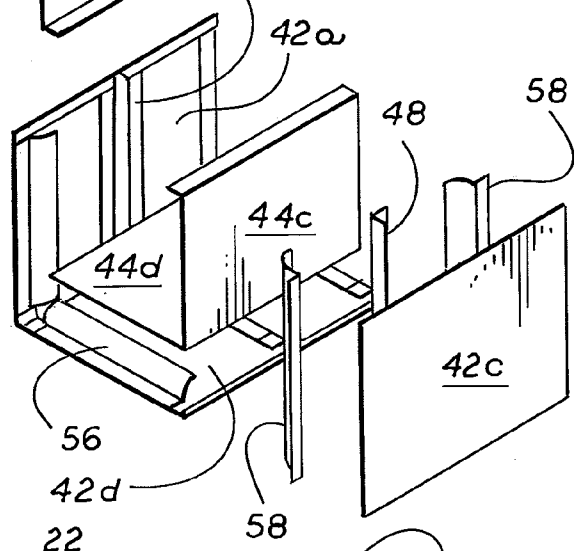


Fig. 6





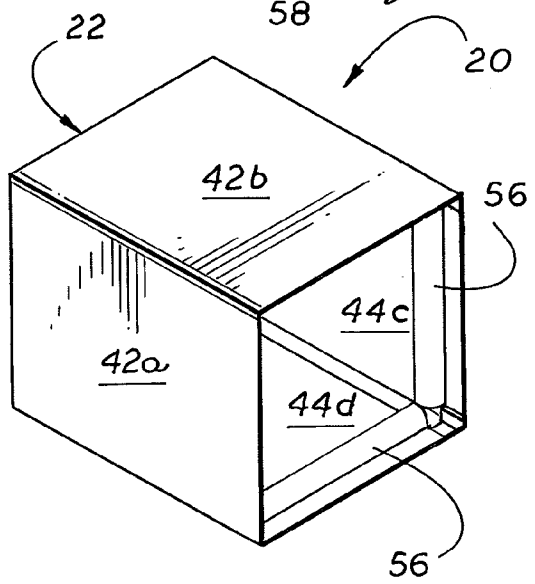


Fig_7

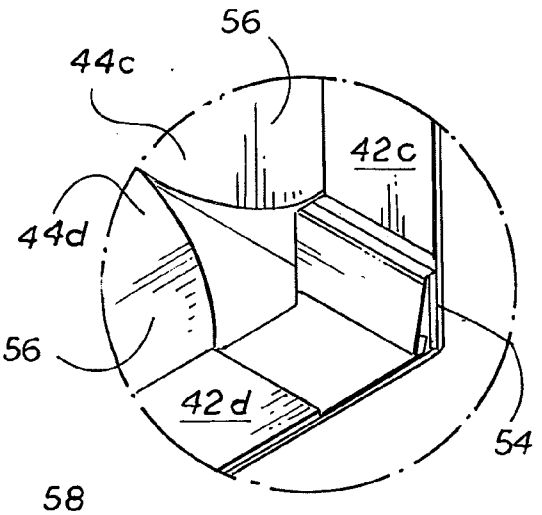


Fig_10

Fig_9

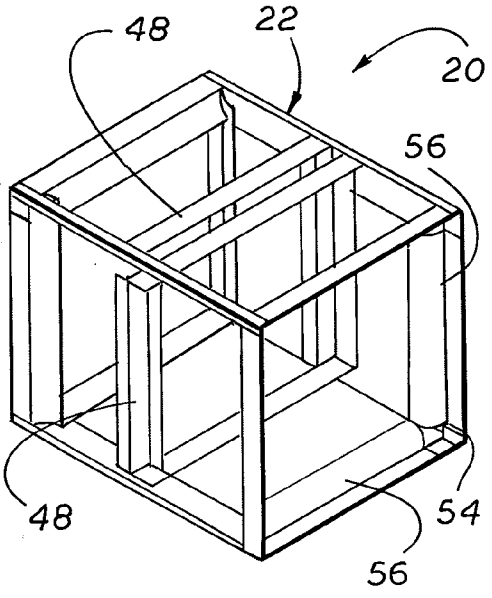


Fig_8

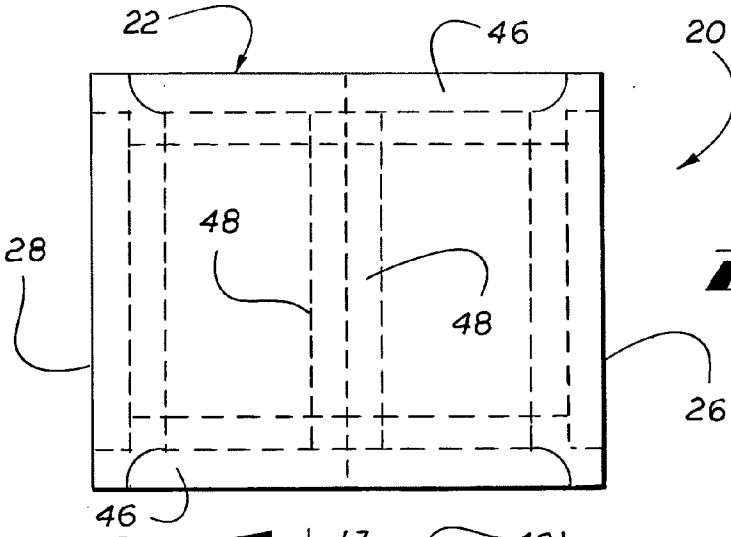


Fig_11

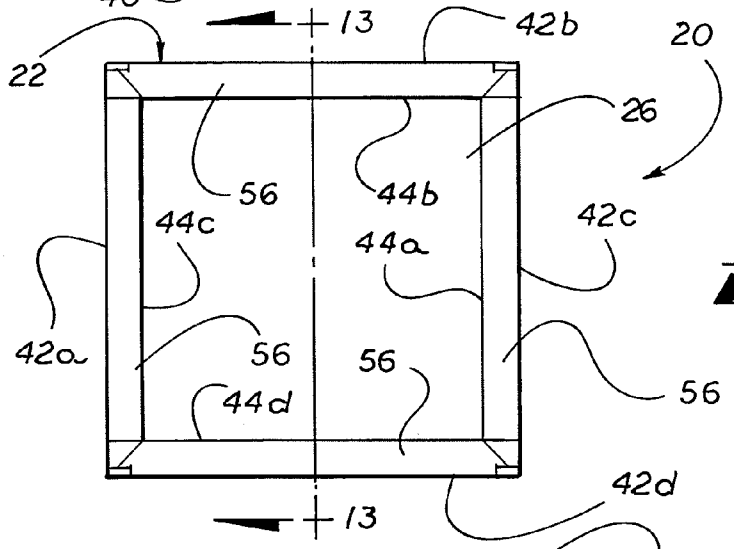


Fig_12

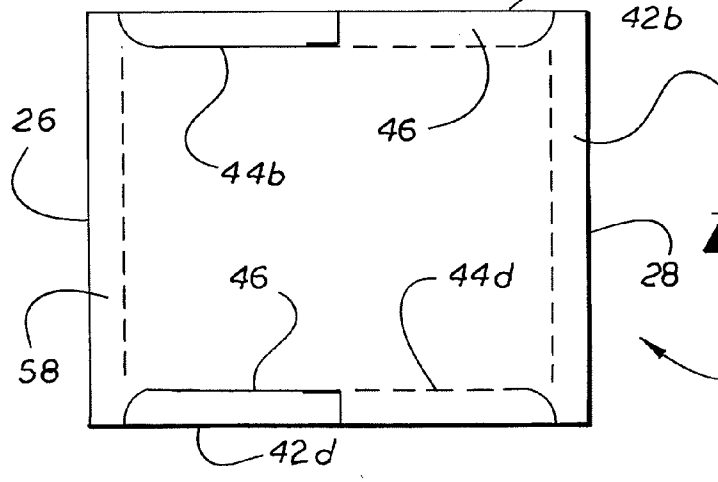


Fig_13

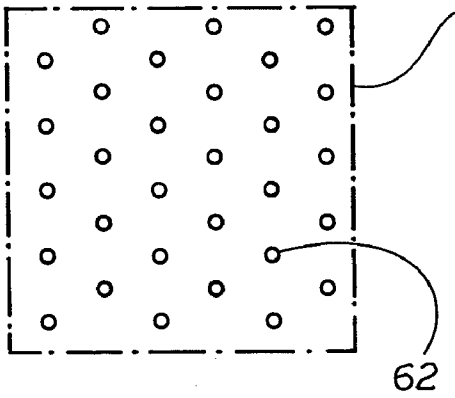


Fig_14A

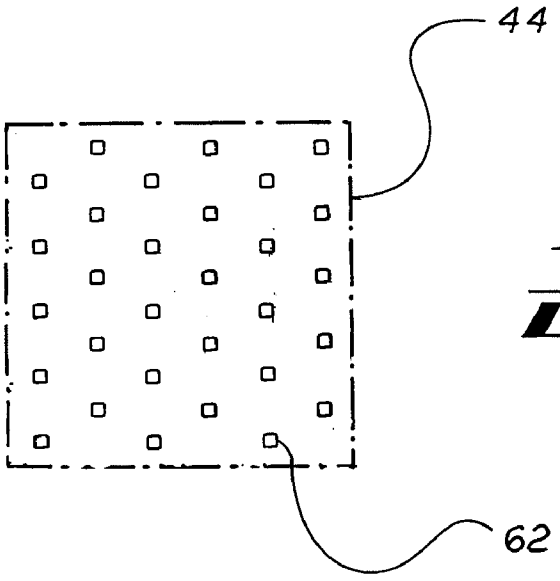


Fig_14B

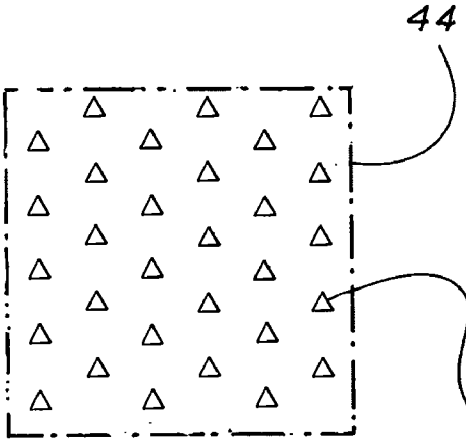


Fig_14C

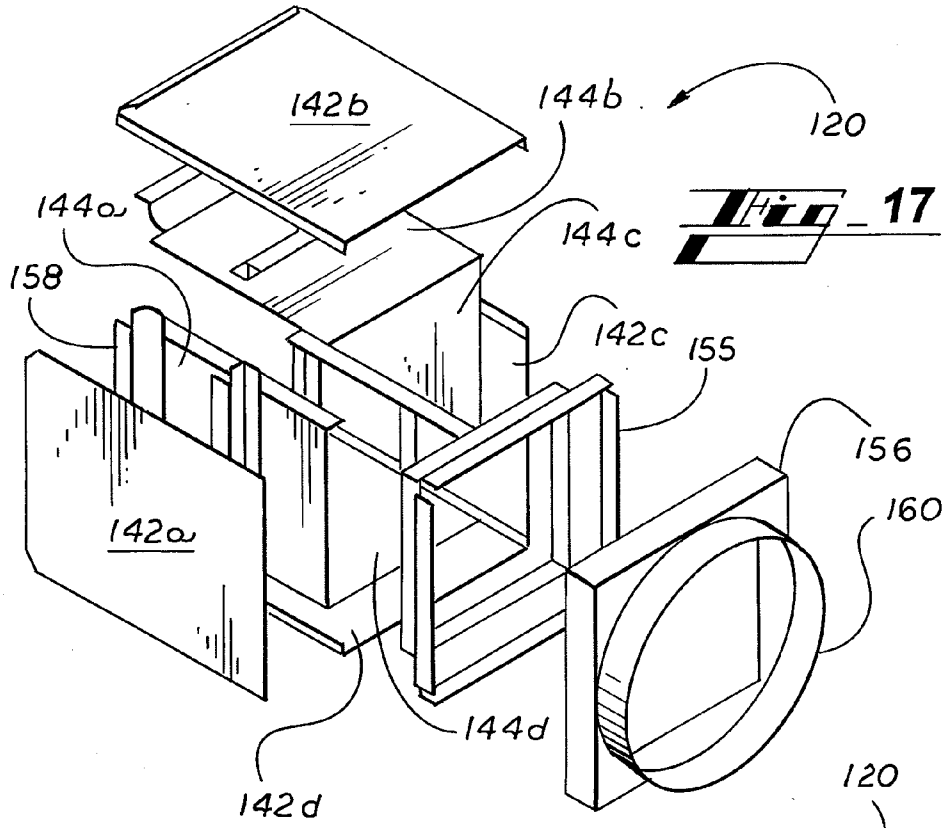


Fig_17

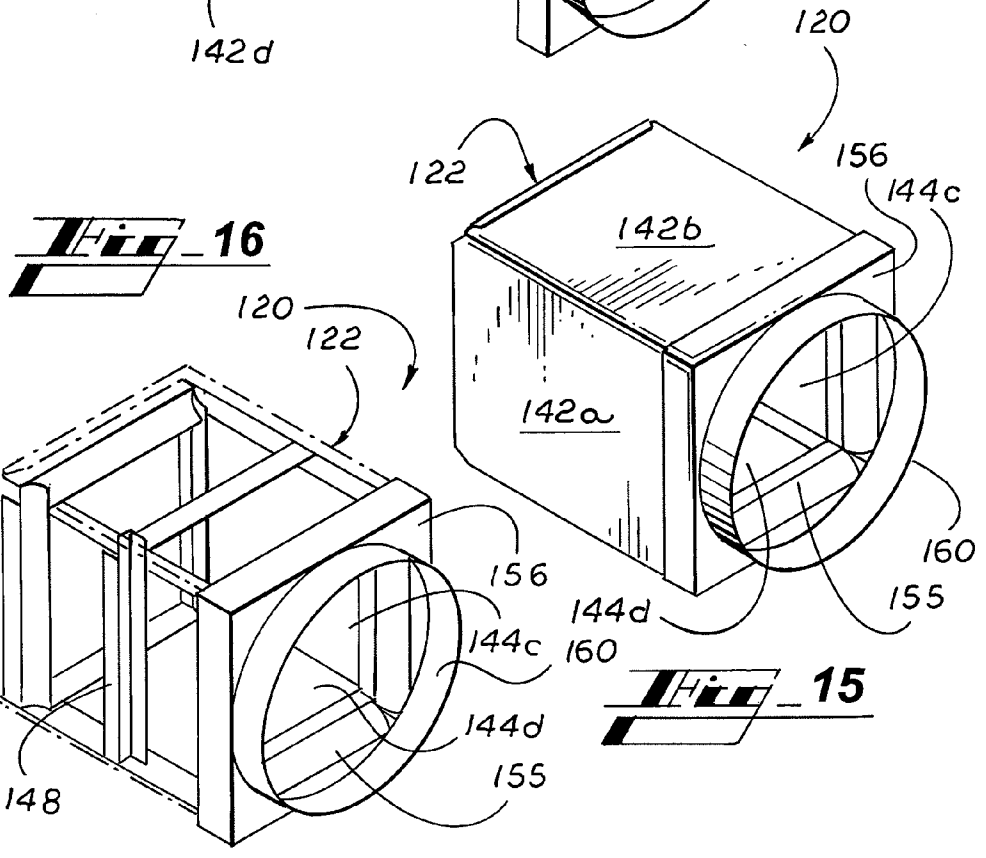


Fig_16

Fig_15

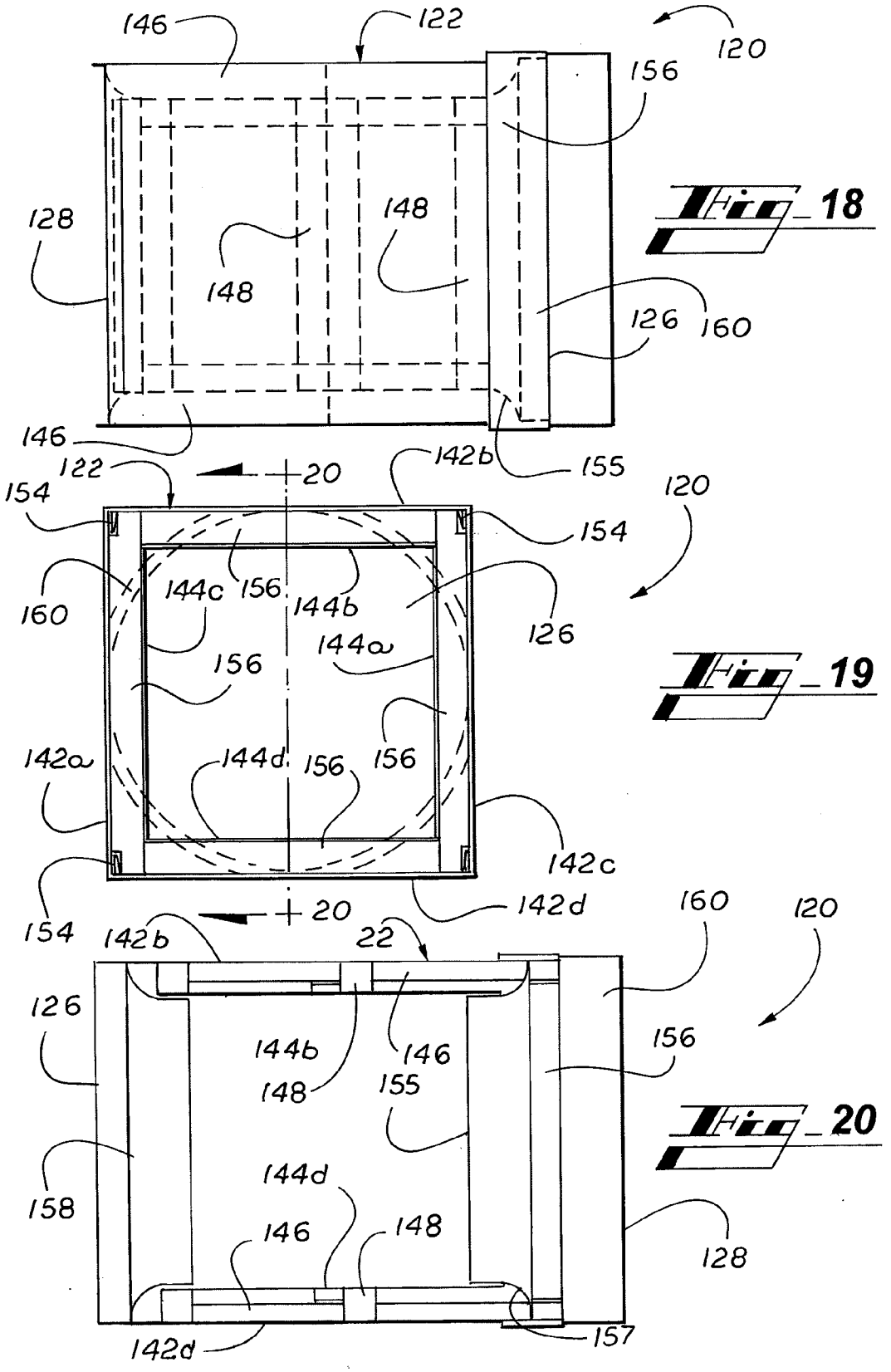


Fig. 18

Fig. 19

Fig. 20

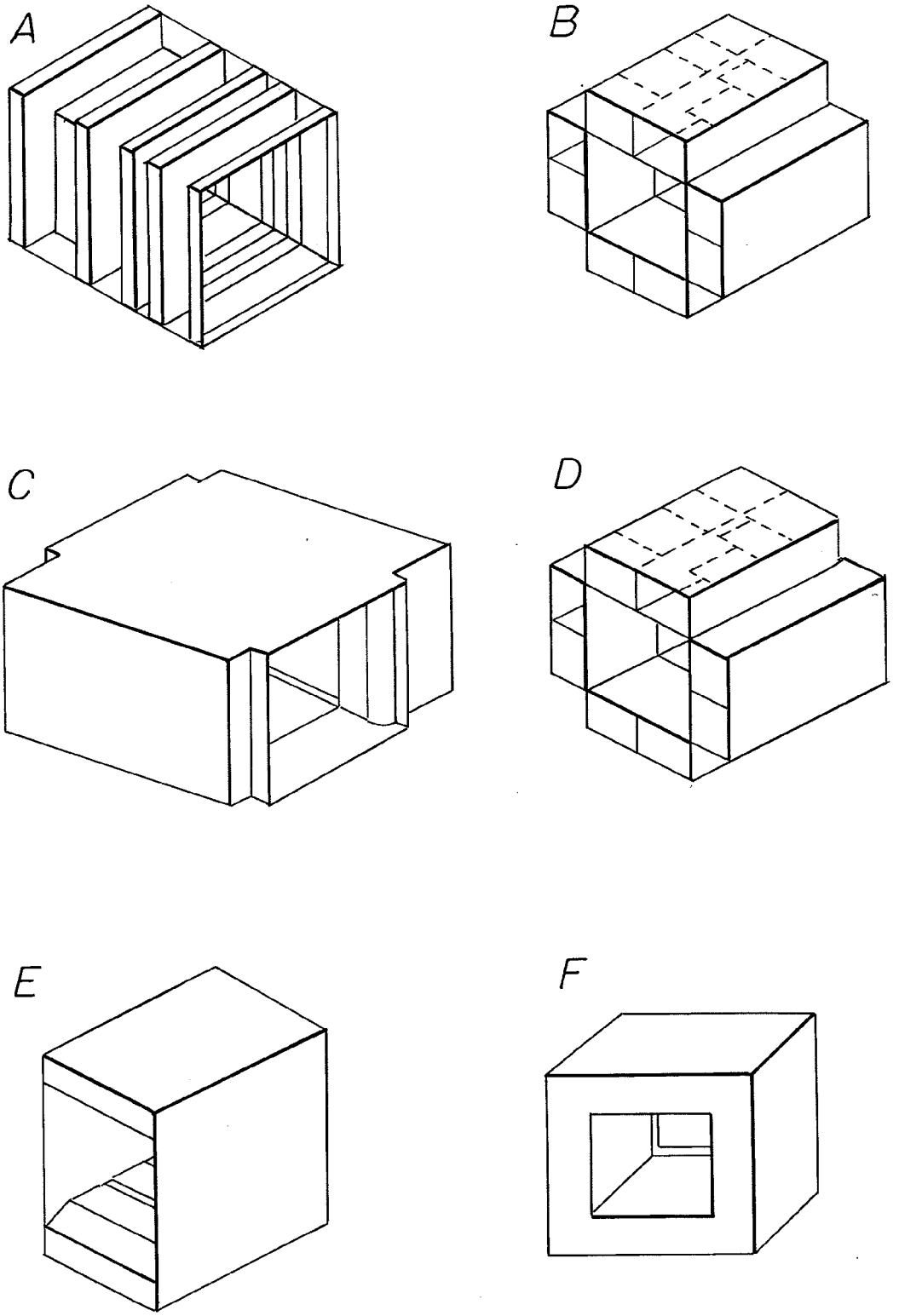


Fig. 21

PACKLESS SILENCER FOR A VENTURI CONTROL VALVE

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This patent application claims priority from U.S. Provisional Patent Application No. 61/477,858, filed Apr. 21, 2011, which is hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] This invention relates to a Venturi control valve that is used to control the flow of air through a duct system of a heating, ventilation, and air-conditioning (HVAC) system, and more particularly, the invention relates to a packless silencer that is closely connected to the Venturi control valve to suppress the noise created by the Venturi control valve.

BACKGROUND OF THE INVENTION

[0003] A conventional HVAC system includes a duct system for directing the flow of air into and out of an occupied space that is heated, ventilated, or cooled by the HVAC system. In order to control the flow of air through one region of the duct system, control valves may be placed within the duct system to limit the flow of air to one region or another of the occupied space. A Venturi control valve, such as that disclosed in Lorch et al. U.S. Patent Application Publication No. 2002/0162589, is conventionally used to control the flow of air through a portion of the duct system. Such a Venturi control valve provides a constant volume of air flow over a range of pressures within the duct system. Such Venturi control valves, however, generate excess noise that may be annoying to persons occupying the space that is heated, ventilated, or cooled by the HVAC system.

[0004] Conventional silencers used with Venturi control valves include Helmholtz resonator silencers, such as that disclosed in Lorch et al. U.S. Pat. No. 6,116,375, packless silencers, such as that disclosed in Ingard U.S. Pat. No. 4,287,962, and silencers packed with acoustical material, such as foam, rock-wool, fiberglass, etc. Typically, silencers for Venturi control valves are spaced away from the Venturi control valve by at least 3 feet or more.

[0005] Therefore, there is a need to suppress the noise created by the Venturi control valves where the available space around the Venturi control valve is limited.

SUMMARY OF THE INVENTION

[0006] In order to suppress the noise created by a conventional Venturi control valve within a limited space, the present invention includes an inlet silencer for the exhaust Venturi control valve or an outlet silencer for the supply Venturi control valve. The inlet silencer comprises four side walls defining a generally, rectangular inlet silencer housing with an intake opening and a discharge opening. Similarly, the outlet silencer comprises four side walls defining a generally, rectangular outlet silencer housing with an intake opening and a discharge opening. The inlet silencer, in accordance with the present invention, is directly connected to an inlet opening of the Venturi control valve, and the outlet silencer, in accordance with the present invention, is directly connected to an outlet opening of the Venturi control valve. The inlet silencer and the outlet silencer are closely coupled to the Venturi control valve, and each is no greater than 24 inches in length (in the air flow direction). Typically in the industry, 3 feet of air duct is interposed between conventional silencers and the Venturi control valve.

[0007] Moreover, the inlet silencer and the outlet silencer are packless silencers with no acoustical material, such as foam, rock-wool, fiberglass etc., installed inside the walls of the inlet silencer and the outlet silencer. Instead, the inlet silencer and the outlet silencer are each lined with perforated metal baffles spaced inwardly approximately one inch from the side walls along the full length of the silencer housing thereby creating a baffle space between the perforated baffles and the side walls. No acoustical material (insulation) is present in the baffle space between the perforated baffles and the side walls of the silencer housing. A set of reinforcing braces are placed approximately in the center of the baffle space between baffles and the side walls, and metal end caps close the ends of the baffle space adjacent the intake openings and the discharge openings of the silencers. The baffles are perforated. Typically, the perforations are in the shape of spaced round holes. Any standard perforation pattern, however, may be employed.

[0008] When compared to conventional silencers used with Venturi control valves, the closely coupled, packless inlet silencer and the closely coupled packless outlet silencer of the present invention perform as well or better than the less space efficient silencers of the prior art.

[0009] Further objects, features and advantages will become apparent upon consideration of the following detailed description of the invention when taken in conjunction with the drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a perspective view of a Venturi control valve with a closely coupled, packless inlet silencer in accordance with the present invention.

[0011] FIG. **2** is a side elevation view of the Venturi control valve (with the internal detail of the Venturi control valve shown in phantom) with the closely coupled, packless inlet silencer in accordance with the present invention.

[0012] FIG. **3** is an end elevation view (as seen looking in the direction opposite the air flow) of the Venturi control valve with the closely coupled, packless inlet silencer in accordance with the present invention.

[0013] FIG. **4** is a perspective view of a Venturi control valve with a closely coupled, packless outlet silencer in accordance with the present invention.

[0014] FIG. **5** is a side elevation view of the Venturi control valve (with the internal detail of the Venturi control valve shown in phantom) with the closely coupled, packless outlet silencer in accordance with the present invention.

[0015] FIG. **6** is an end elevation view (as seen looking in the direction of the air flow) of the Venturi control valve with the closely coupled, packless outlet silencer in accordance with the present invention.

[0016] FIG. **7** is a perspective view of the packless inlet silencer or the packless outlet silencer in accordance with the present invention.

[0017] FIG. **8** is a perspective view of the packless inlet silencer or the packless outlet silencer with the outside walls removed to show internal detail in accordance with the present invention.

[0018] FIG. **9** is an exploded view of the packless inlet silencer or the packless outlet silencer in accordance with the present invention.

[0019] FIG. **10** is a detailed perspective view of a corner of the packless inlet silencer or the packless outlet silencer in accordance with the present invention.

[0020] FIG. **11** is a side elevation view of the packless inlet silencer or the packless outlet silencer in accordance with the present invention showing internal detail in broken lines.

[0021] FIG. **12** is an end elevation view of the packless inlet silencer or the packless outlet silencer in accordance with the present invention.

[0022] FIG. **13** is a section view of the packless inlet silencer or the packless outlet silencer in accordance with the present invention as seen along line **13-13** of FIG. **12**.

[0023] FIGS. **14**A, **14**B, and **14**C are detailed plan views of perforation patterns that are suitable for the baffles of the packless inlet silencer or the packless outlet silencer in accordance with the present invention.

[0024] FIG. **15** is a perspective view of a second embodiment of a packless inlet silencer in accordance with the present invention.

[0025] FIG. **16** is a perspective view of the second embodiment of the packless inlet silencer with the outside walls removed to show internal detail in accordance with the present invention.

[0026] FIG. **17** is an exploded view of the second embodiment of the packless inlet silencer in accordance with the present invention.

[0027] FIG. **18** is a side elevation view of the second embodiment of the packless inlet silencer in accordance with the present invention showing internal detail in phantom.

[0028] FIG. **19** is an end elevation view of the second embodiment of the packless inlet silencer in accordance with the present invention.

[0029] FIG. **20** is a section view of the second embodiment of the packless inlet silencer in accordance with the present invention as seen along line **20-20** of FIG. **19**.

[0030] FIG. **21** is a series of sketches showing alternative silencer constructions that are not in accordance with the present invention and are the subject of testing reported in Tables 1 and 2 below.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0031] Turning to FIGS. **1-3**, a Venturi control valve **12** is conventional in construction and is used in a HVAC duct system to control the flow of air within an HVAC duct system. Particularly, the Venturi control valve **12** provides constant air flow over a range of pressure within the HVAC duct system. The Venturi control valve **12**, however, may create a level of noise that may be unacceptable to occupants of space that is served by the duct system that includes the Venturi control valve **12**. The Venturi control valve **12** has an inlet opening **14** and an outlet opening **16**. In order to reduce noise generated by the Venturi control valve **12**, the inlet opening **14** of the Venturi control valve **12** is closely coupled to an inlet silencer **20**. Alternatively, with reference to FIGS. **4-6**, the outlet opening **16** of the Venturi control valve **12** is closely coupled to an outlet silencer **30** in order to reduce noise created by the Venturi control valve **12**.

[0032] As shown in FIG. **2**, the inlet silencer **20** has an intake opening **26** and a discharge opening **28**. The discharge opening **28** is closely coupled to the inlet opening **14** of the Venturi control valve **12**. The length of the inlet silencer **20** is 14.25 inches in the direction of the air flow into the Venturi control valve **12**, but the inlet silencer **20** may be as long as 24 inches. Similarly, as shown in FIG. **5**, the outlet silencer **30** has an intake opening **36** and a discharge opening **38**. The inlet opening **36** is closely coupled to the outlet opening **16** of the Venturi control valve **12**. The length of the outlet silencer **30** is no greater than 14.25 inches in the direction of the air flow out of the Venturi control valve **12**, but the outlet silencer **30** may be as long as 24 inches.

[0033] FIGS. **7-14** show the construction of either the inlet silencer **20** or the outlet silencer **30**. For the purposes of discussion, FIGS. **7-14** will refer to the inlet silencer **20**, although the description has equal applicability to the outlet silencer **30**. The inlet silencer **20** comprises a generally rectangular housing **22** formed by four side walls **42***a*, **42***b*, **42***c*, and **42***d*. The four side walls **42***a*, **42***b*, **42***c*, and **42***d* are joined together to form the housing **22** by a crimped seam connection **54** shown in detail in FIG. **10**. The intake opening **26** and the discharge opening **28** of the inlet silencer **20** are at opposite ends of the rectangular housing **22** and are best identified in FIGS. **11** and **13**.

[0034] Perforated baffles **44***a*, **44***b*, **44***c*, and **44***d* are mounted along the full length of the inside of the inlet silencer **20** by means of intake baffle end caps **56**, discharge baffle end caps **58**, and intermediate reinforcing braces **48** shown in FIGS. **7**, **8**, **9**, and **11**. The baffles are spaced approximately 1 inch from the inside of each of the four side walls **42***a*, **42***b*, **42***c*, and **42***d* and thereby form an approximately 1 inch baffle space **46** (FIGS. **11** and **13**) between the four baffles **44***a*, **44***b*, **44***c*, and **44***d* and the four side walls **42***a*, **42***b*, **42***c*, and **42***d*. The baffle space **46** is empty without any acoustical material or packing. The baffle space **46** has end openings adjacent the intake opening **26** and the discharge opening **28** of the inlet silencer **20**. The end openings of the baffle spaces are covered by the four intake baffle end caps **56** and the four discharge baffle end caps **58** (FIGS. **8**, **9**, **12**, and **13**).

[0035] Each of the four perforated baffles **44***a*, **44***b*, **44***c*, and **44***d* may be perforated with one of the illustrative perforation patterns shown in FIGS. **14**A, **14**B, and **14**C. The perforation patterns shown in FIGS. **14**A, **14**B, and **14**C consist of a series of spaced triangular, rectangular, and circular holes **62**. The holes **62** occupy approximately 10% of the area of each of the perforated baffles **44***a*, **44***b*, **44***c*, and **44***d*. Other hole shapes and hole patterns may perform equally well.

[0036] Table 1 and Table 2 below illustrate the performance of the silencers, either inlet silencer **20** or outlet silencer **30**, in accordance with the present invention when closely coupled to a Venturi control valve **12**. In the Tables, the silencer **20** or the silencer **30** in accordance with the present invention is designated "J" and is shown in the sketch below Table 2. The other silencers are shown below Table 2 and are designated A-E. The Tables also show the performance of certain competitive silencers designated XYZ. The competitive silencers were closely coupled to the Venturi control valve **12**.

TABLE 1

100909 Prov Pat Coaxial Inlet_Outlet/Tables

			PWL, dB ref 1 picoWatt							
	Orifice	Static	Octave Band							Peak
Silencer	[CFM]	H2O	2	3	4	5	6	7	NC Rating	Band
None	1000	1.5	77	68	67	73	69	66	59	5
A	990	1.5	72	67	59	61	64	60	51	6
B	990	1.5	65	61	58	67	64	60	53	5
C	990	1.5	65	62	56	66	64	61	52	5
D	990	1.5	65	65	60	67	64	60	53	5

TABLE 1-continued

100909 Prov Pat Coaxial Inlet_Outlet/Tables

			PWL, dB ref 1 picoWatt							
	Orifice	Static	Octave Band							Peak
Silencer	[CFM]	H2O	2	3	4	5	6	7	NC Rating	Band
E	990	1.5	68	61	60	68	65	61	54	5
	990	1.5	67	62	59	56	52	51	42	5
	990	1.5	66	65	60	66	62	57	52	5
	990	1.5	66	62	58	54	52	51	39	5

TABLE 2

Difference in Sound Power

	2	3	4	5	6	7	Delta NC
A	5	2	8	12	5	7	8
B	12	7	9	6	5	6	6
C	12	6	11	7	5	5	7
D	12	3	7	6	5	6	6
E	9	7	7	5	4	5	5
J	10	6	8	17	17	15	17
XYZ Valve	11	3	7	7	7	9	7
XYZ w/Silencer	0	3	3	12	10	6	13

[0037] FIGS. **15-20** show the construction of an alternate embodiment of an inlet silencer **120**. The inlet silencer **120** comprises a generally rectangular housing **122** formed by four side walls **142***a*, **142***b*, **142***c*, and **142***d*. The four side walls **142***a*, **142***b*, **142***c*, and **142***d* are joined together to form the housing **122** by a crimped seam connection **154**. An intake opening **126** and a discharge opening **128** of the inlet silencer **120** are shown in FIGS. **18** and **20**.

[0038] Perforated baffles **144***a*, **144***b*, **144***c*, and **144***d* are mounted along the full length of the inside of the inlet silencer **120** by means of intake baffle rounded end caps **155**, discharge baffle end caps **158**, and intermediate reinforcing braces **148** shown in FIGS. **15**, **16**, **17**, **18**, and **20**. The baffles **144***a*, **144***b*, **144***c*, and **144***d* are spaced approximately 1 inch from the inside of each of the four side walls **142***a*, **142***b*, **142***c*, and **142***d* and thereby form an approximately 1 inch baffle space **146** (FIGS. **18** and **20**) between the four baffles **144***a*, **144***b*, **144***c*, and **144***d* and the four side walls **142***a*, **142***b*, **142***c*, and **142***d*. The baffle space **146** is empty without any acoustical material or packing. The baffle space **146** has end openings adjacent the intake opening **126** and the discharge opening **128** of the inlet silencer **120**. The end openings of the baffle spaces are covered by the four intake baffle end caps **155** and the four discharge baffle end caps **158** (FIGS. **16**, **17**, and **19**). The intake baffle end caps **155** have a rounded surface **157** that contributes to the smooth transition of the air through the intake opening **126** and into the housing **122** of the inlet silencer **120**. The inlet silencer **120** further has an external end cap **156** that fits over the intake end of the housing **122**. The external end cap **156** further includes a round duct connector **160** for connecting the inlet silencer **20** to the heating and air-conditioning duct of the HVAC system.

[0039] Each of the four perforated baffles **144***a*, **144***b*, **144***c*, and **144***d* are perforated with one of the perforation patterns shown in FIGS. **14**A, **14**B, and **14**C.

[0040] As illustrated herein, the expression "closely coupled" means that the inlet silencer **20** and the outlet silencer **30** are each directly attached to the Venturi control valve **12** without any substantial length of duct without baffles **44** interposed between the Venturi control valve and either the inlet silencer **20** or the outlet silencer **30**.

[0041] While this invention has been described with reference to preferred embodiments thereof, it is to be understood that variations and modifications can be affected within the spirit and scope of the invention as described herein and as described in the appended claims.

I claim:

1. A packless silencer for close connection to a Venturi control valve, the packless silencer comprising:

a. an enclosed housing having side walls, an intake opening, a discharge opening, and a length;

b. a perforated baffle corresponding to each of the side walls and positioned inside of the housing wherein each perforated baffle:

i. extends the length of the housing;

ii. is offset from the corresponding side wall to form a baffle space between the perforated baffle and the corresponding side wall; and

iii. has a perforation pattern, and

c. baffle end caps to seal the baffle space adjacent the intake opening and the discharge opening.

2. The packless silencer of claim **1**, wherein the baffle space is empty.

3. The packless silencer of claim **1**, wherein baffle end caps are rounded.

4. The packless silencer of claim **1**, wherein the packless silencer is less than 24 inches in length in a direction of air flow through the packless silencer.

5. The packless silencer of claim **1**, wherein the perforated baffle has an area, and the perforation pattern comprises holes in the perforated baffle that occupy approximately 10% of the area of the perforated baffle.

6. A duct control valve comprising:

a. a Venturi control valve having an inlet opening and an outlet opening;

b. a packless silencer closely connected to either the inlet opening or the outlet opening of the Venturi control valve, the packless silencer comprising:

i. an enclosed housing having side walls, an intake opening, a discharge opening, and a length;

ii. a perforated baffle corresponding to each of the side walls and positioned inside of the housing wherein each perforated baffle:

(a) extends the length of the housing;

(b) is offset from the corresponding side wall to form a baffle space between the perforated baffle and the corresponding side wall; and

(c) has a perforation pattern,

iii. baffle end caps to seal the baffle space adjacent the intake opening and the discharge opening.

7. The duct control valve of claim **6**, wherein the baffle space is empty.

8. The duct control valve of claim **6**, wherein baffle end caps are rounded.

9. The duct control valve of claim **6**, wherein the packless silencer is less than 24 inches in length in a direction of air flow through the packless silencer.

10. The duct control valve of claim **6**, wherein the perforated baffle has an area, and the perforation pattern comprises holes in the perforated baffle that occupy approximately 10% of the area of the perforated baffle.

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