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(54) **NVH AND GAS PULSATION REDUCTION IN AC COMPRESSOR**

(75) Inventor: **Fwutsai J. Kuo**, Novi, MI (US)

(73) Assignee: **Visteon Global Technologies, Inc.**, Dearborn, MI (US)

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(52) **U.S. Cl.** **417/312**; 417/269; 181/403; 181/240

(58) **Field of Search** 181/403, 264, 181/282, 275, 240, 229, 272, 202; 417/269, 312, 540

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,817,661 A * 6/1974 Ingalls et al. 417/312
4,930,995 A * 6/1990 Suzuki et al. 417/312
4,936,754 A * 6/1990 Suzuki et al. 417/269
5,244,355 A * 9/1993 Fujii et al. 417/269
5,466,129 A * 11/1995 Fukai 417/269
5,645,405 A 7/1997 Ota et al.
5,702,236 A 12/1997 Ikeda
5,704,769 A * 1/1998 Michiyuki et al. 417/269
6,293,768 B1 9/2001 Shintoku et al.
6,382,938 B1 5/2002 Murao et al.
6,390,786 B1 5/2002 Gennami et al.
6,402,483 B1 6/2002 Kawamura et al.

FOREIGN PATENT DOCUMENTS

EP 1033492 9/2000
EP 1184569 3/2002

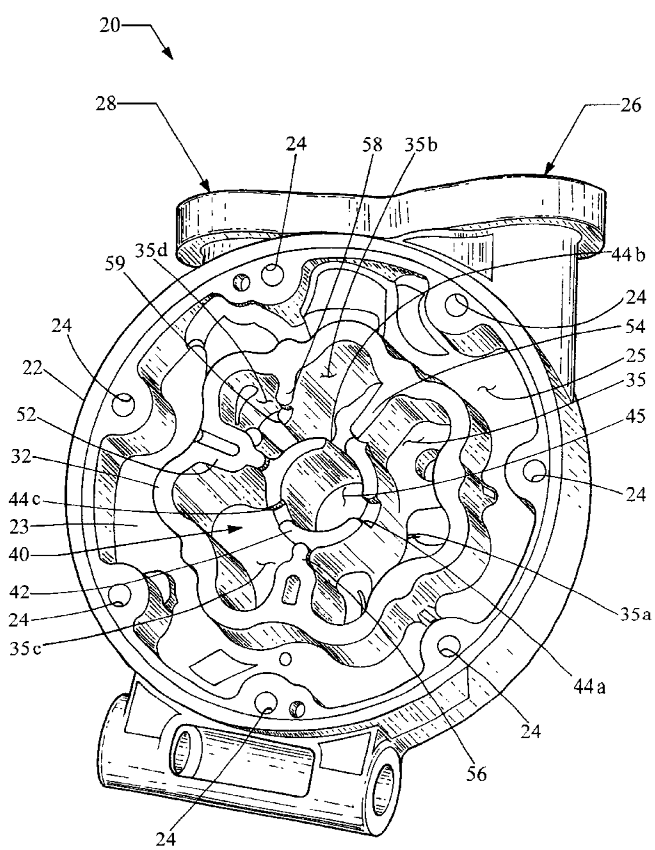
* cited by examiner

Primary Examiner—Justine R. Yu
Assistant Examiner—Timothy P. Solak
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

A muffler is integrally incorporated into the rear housing of a compressor. In this way, the muffler reduces the overall size, weight and cost of the compressor. The fluid flow is directed through the muffler and discharge chamber in such a way as to fully utilize the volume effectively to reduce flow turbulence, while not causing any significant flow loss or delay in fluid supply.

20 Claims, 3 Drawing Sheets



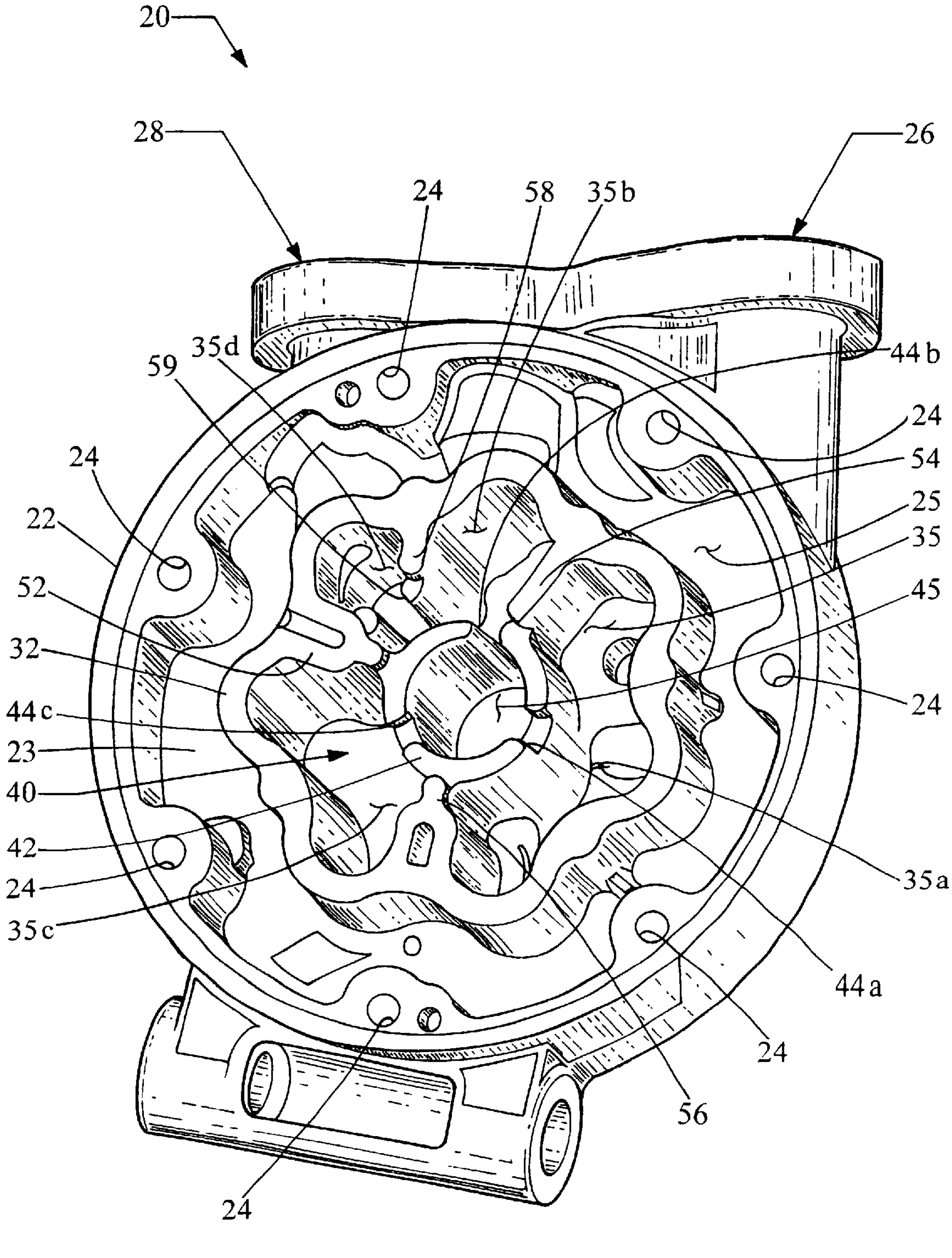

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Fig. 1

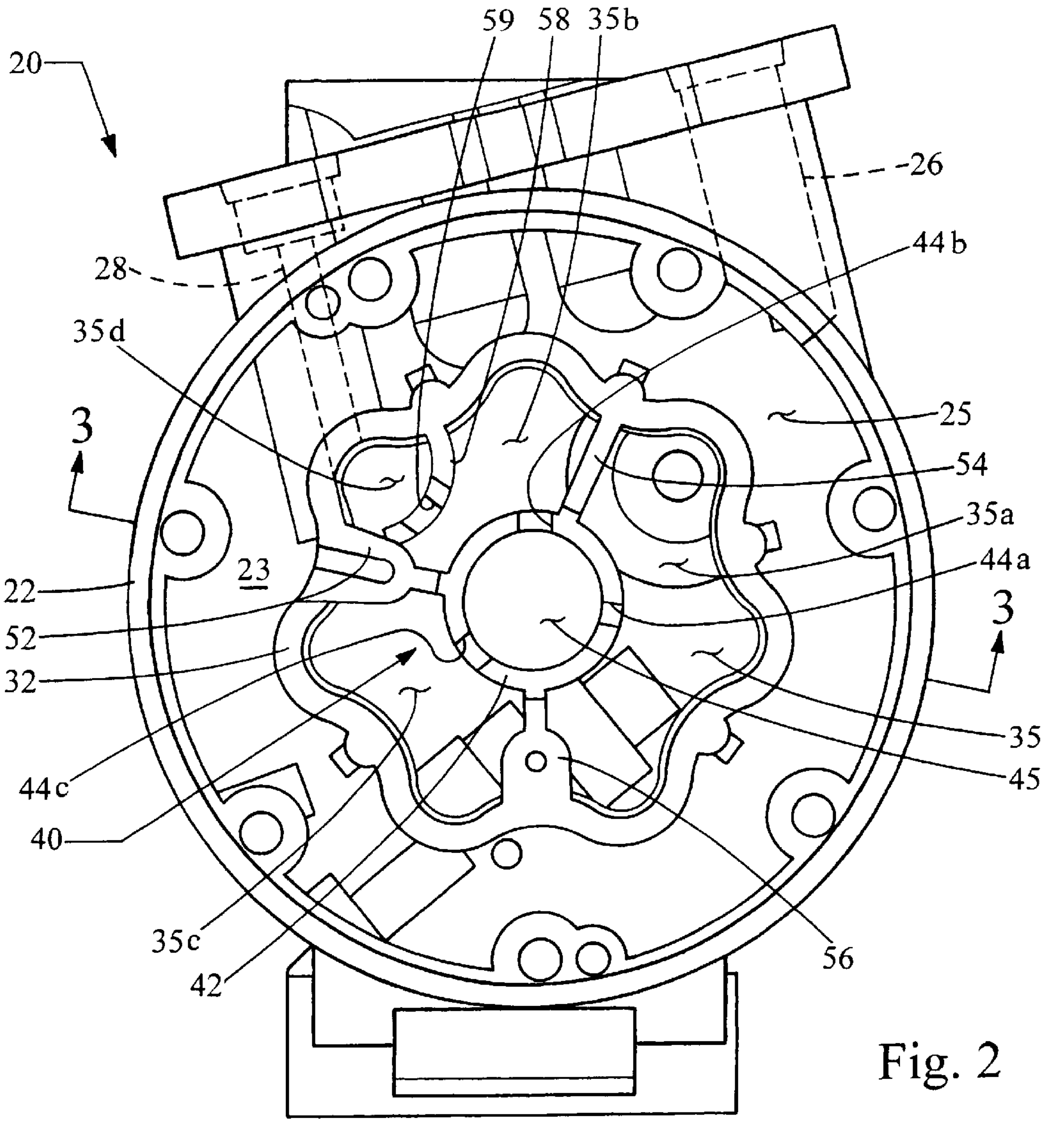
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Fig. 2

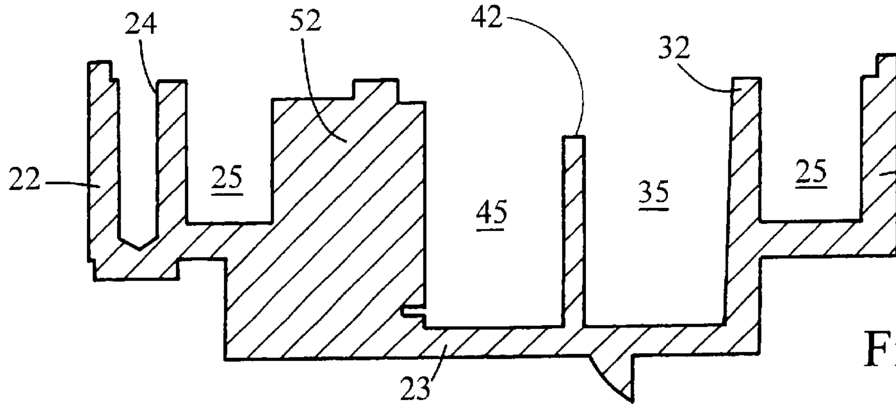
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Fig. 3

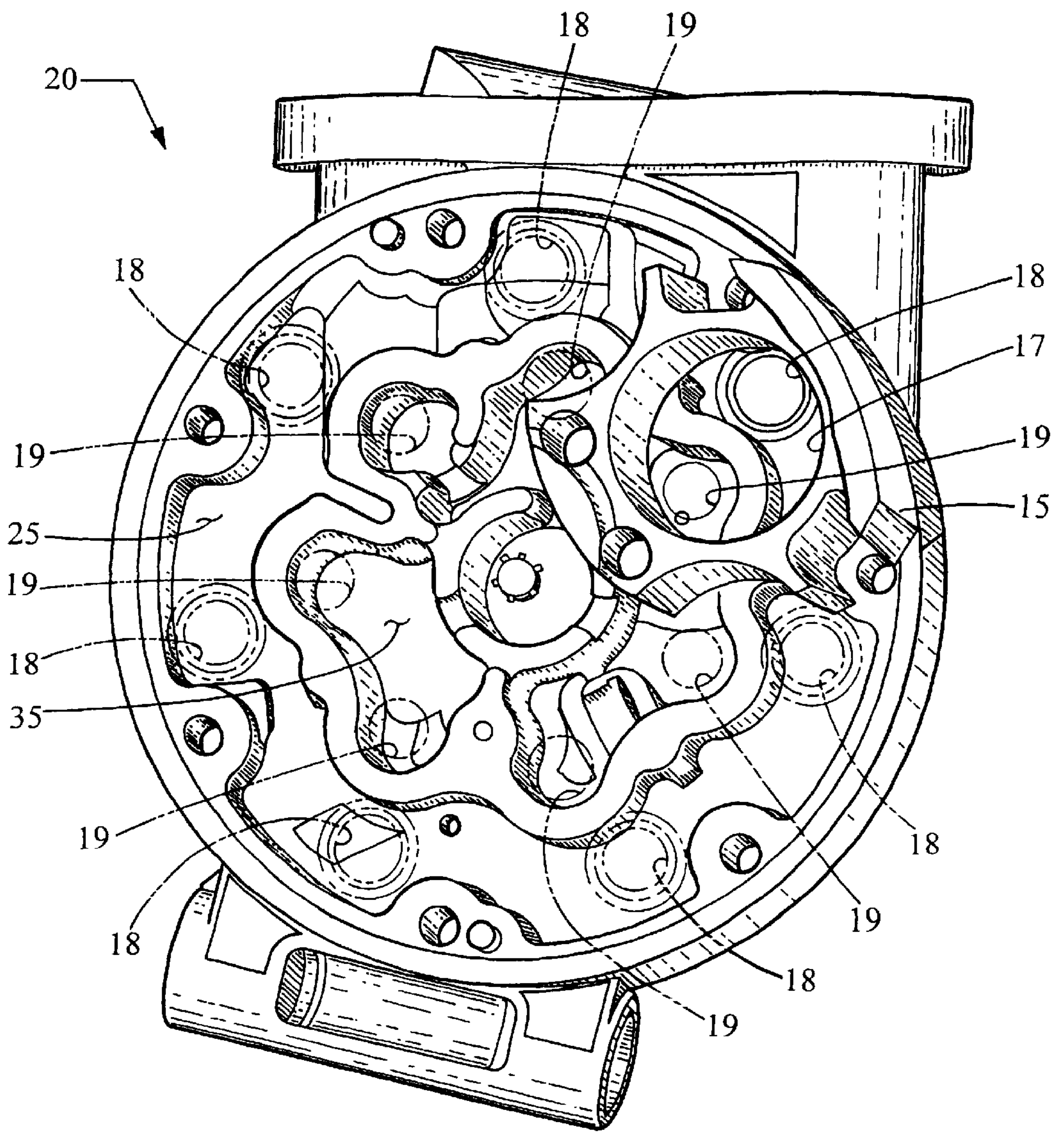

Fig. 4

NVH AND GAS PULSATION REDUCTION IN AC COMPRESSOR

FIELD OF THE INVENTION

The present invention relates generally to compressors, and more particularly relates to mufflers for reducing noise in compressors.

BACKGROUND OF THE INVENTION

Existing compressors, such as air conditioning compressors found in vehicles, are relatively noisy. Accordingly, many compressors include a built-in flow noise control device or muffler. Unfortunately, these devices are usually a bulky addition to the compressor casting or housing, increasing the overall size and mass of the compressor significantly. Furthermore, these mufflers typically communicate with the discharge flow or the suction flow through a long and narrow passage. This passage is strictly a communication channel, and does not direct flow in a manner that effectively utilizes the interior of the muffler. One drawback includes a large flow loss due to the structure of the communication channel. Flow loss refers to a pressure loss in the flow due to the restricted flow passage. The more flow loss, the more power is required to compress same amount of refrigerant through a passage. Therefore, there exists a need to provide a muffler for a compressor that not only reduces the flow loss through the muffler, but which also reduces the overall size, weight and cost of the compressor.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a muffler for a compressor that is incorporated into the existing rear housing portion of the compressor housing. In this way, the present invention provides a compressor which has reduced size and weight compared to existing compressors with external mufflers, mufflers as well as reducing the amount of flow loss. In turn, the efficiency of the compressor is increased (i.e. lower power consumption) due to streamlined flow with less turbulence. Additionally, the integral muffler adds stiffness to the rear housing that attributes to lower vibration. Preferably, a muffler chamber is defined within a discharge chamber, and the discharge chamber is further sub-divided into first and second portions. Discharge flow entering the first portion of the discharge chamber must flow through the muffler chamber before reaching the second portion of the discharge chamber for exit through a discharge port. Generally, the muffler chamber is defined by a muffler wall which includes restrictions to regulate the flow from the first portion to the second portion of the discharge chamber. Additional features include further subdividing the discharge chamber into several smaller cavities, as well as providing high pressure fluid directly to the second portion and discharge port.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. In the drawings:

FIG. **1** is a perspective view of a rear housing and muffler constructed in accordance with the teachings of the present invention; [insert a brief description of each drawing, being sure that each drawing is separately labeled (e.g., **1**, **2A**, **2B**, **3**, **4**, etc.) and individually described].

FIG. **2** is a top view of the rear housing and muffler depicted in FIG. **1**;

FIG. **3** is a cross-sectional view taken about the line **3—3** of FIG. **2**; and

FIG. **4** is a perspective view similar to FIG. **1**, but depicting a portion of a cylinder block partially cut away.

While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to the figures, FIGS. **1–3** illustrate a rear housing **20** having a muffler **40** for reducing the noise, vibration and harshness in a compressor (not shown). Generally, the muffler **40** provides a damping effect to reduce the turbulence of fluid flow, as well as any pulsations in the flow. As a result of reduced flow turbulence and pulsations, the noise and vibration are reduced. Further, the efficiency of the compressor is increased due to the streamlined flow having less turbulence.

The rear housing **20** forms one element of a housing for the compressor. The rear housing **20** includes an end wall **26** and is positioned at one end of the compressor for communicating flow into and out of the compressor. The rear housing **20** includes an outer wall **22** extending axially from the end wall **26** around its outer periphery. The outer wall **22** is annular in shape. As used herein, "annular" refers to a ring-shape structure (i.e. having no particular beginning or end), although not necessarily circular.

The outer wall **22** defines a plurality of female connectors shown as threaded openings **24**. Typically, a threaded fastener is utilized to connect the rear housing **20** to the main housing by way of the threaded openings **24**. As shown in FIG. **4**, the rear housing is positioned immediately downstream of a cylinder block **15** containing a plurality of pistons (not shown) reciprocating within their respective bores **17**. The cylinder block **15** has been shown partially cut-away in FIG. **4**. As will be described in more detail herein, the rear housing **20** supplies low pressure fluid to the compressor, and more particularly the piston bores **17**, as well as directs high pressure fluid produced by the compressor and discharged via the bores **17**.

To accomplish the above, an inner wall **32** is formed within the rear housing **20**. As with the outer wall **22**, the inner wall **32** extends axially from the end wall **26** of the rear housing **20**. The inner wall **32** is completely circumscribed by the outer wall **22**. The inner wall **32** is annular in shape, and more specifically the inner wall **32** is flower-shaped, having a plurality of peaks and troughs to facilitate cooperation with the input and output of the cylinder bores **17**, as shown in FIG. **4**. The volume between the outer wall **22** and the inner wall **32** defines a suction chamber **25** which is utilized to supply low pressure fluid to the compressor. The supply of low pressure fluid is provided via a suction port **26** which is in fluid communication with the suction chamber **25**, as best seen in FIG. **2**. Within the inner wall **32**, and as will be described in more detail herein, a discharge chamber **35** is formed for receiving high pressure fluid from the compressor. The discharge chamber **35** is in fluid communication with a discharge port **28** as shown by the dotted lines of FIG. **2**.

In accordance with the present invention, a muffler **40** is integrally formed within the rear housing **20** to reduce the noise, vibration and harshness of the fluid flow. As shown in the figures, the muffler **40** includes a muffler wall **42** that extends axially from the end wall **26**. The muffler wall **40** is annular in shape, and as shown in the figures, is preferably circular in shape. The muffler wall **42** is located within the inner wall **32** and is completely circumscribed thereby. Thus, the muffler chamber **45** is completely circumscribed by the discharge chamber **35**. Accordingly, the discharge chamber **35** is best defined as the volume between the inner wall **32** and the muffler wall **42**, although it will be recognized that discharge fluid does flow through both the discharge chamber **35** and muffler chamber **45**. Thus, the discharge chamber **35** is ring-shaped and is completely circumscribed by the suction chamber **25**. The muffler wall **42** defines an interior volume defined as the muffler chamber **45**.

As the muffler **40** is incorporated into the rear housing **20** and the discharge chamber **35**, it can be seen that the total outside dimensions of the rear housing **20** remain unchanged. The aforementioned walls (as well as the chambers, ports and channels that they define to direct the fluid flow) are cast directly into the rear housing **20**, which eliminates any additional machining operations. Further, the refrigerant flow is directed to flow through the discharge chamber **35** in muffler **40** in such a way as to fully utilize the internal volume effectively, reducing flow turbulence and pulsations which in turn reduces the noise and vibration. The integral formation of the muffler adds stiffness to the rear housing that attributes to lower vibration.

For directing the flow, at least two divider walls **52**, **54** extend between the muffler wall **42** and the inner wall **32**. As shown in the figures, the illustrated embodiment of the rear housing **20** and muffler **40** includes a third divider wall **56** that extends between the muffler wall **42** and the inner wall **32**. The divider walls **52**, **54**, **56** are spaced apart to subdivide the discharge chamber **35** into first, second and third portions denoted as **35***a*, **35***b* and **35***c*, respectively. The second portion **35***b* of the discharge chamber **35** is fluidically connected with the discharge port **28** for the transfer of high pressure fluid. The first and third portions **35***a*, **35***c* of the discharge chamber **35** are not in direct fluid communication with each other or the second portion **35***b*, but rather are in fluid communication with the muffler chamber **45**. As best seen in FIG. **1**, the muffler wall **42** includes a first opening **44***a* connecting the first portion **35***a* to the muffler chamber **45**. The muffler wall **42** also defines a second opening **44***b* fluidically connecting the second portion **35***b* to the muffler chamber **45**. As the muffler wall **42** is completely annular, it has a wall portion positioned between the second portion **35***b* of the discharge chamber **35** and the muffler chamber **45**. Finally, the muffler wall **42** defines a third opening **44***c* fluidically connecting the third portion **35***c* to the muffler chamber **45**.

In the illustrated embodiment, the second portion **35***b* of the discharge chamber **35** further includes a shield wall **58** within the second portion **35** to define a shield chamber **35***d*. The shield wall **58** includes an opening **59** fluidically connecting the second portion **35***b* of the discharge chamber **35** to the shield chamber **35***d*. The shield chamber **35***d* is directly connected for fluidic communication with the discharge port **28**.

In operation, the cylinder bores **17** suck fluid from the suction chamber **25** at a relatively low pressure (supplied by suction port **26**). The compressor and its cylinder pistons pressurize the fluid and discharge relatively high pressure fluid into the discharge chamber **35**. As shown in FIG. **4**, the cylinder block **15** includes a plurality of cylinder bores **17**.

At one end of each bore **17** the cylinder block **15** defines a suction opening **18** and a discharge opening **19**. Typically, the flow through the suction openings **18** and the discharge openings **19** are regulated by one-way valves to ensure the proper direction of flow. As illustrated, the rear housing **20** is designed for use with a cylinder block **15** having seven cylinder bores **17** and seven sets of suction and discharge openings **18**, **19**.

Accordingly, it can be seen that the compressor discharges high pressure fluid through the discharge openings **19** into the discharge chamber **35**, and more particularly into the first portion **35***a*, second portion **35***b*, third portion **35***c*, and the shield chamber **35***d*. The high pressure fluid in the first and third portions **35***a*, **35***c* of the discharge chamber **35** are required to flow through the first and third openings **44***a*, **44***c* and into the muffler chamber **45**. This fluid flow then follows a path through the second opening **44***b* in the muffler wall **42** and into the second portion **35***b* of the discharge chamber **35**. Flow then follows a path through the opening **59** in the shield wall **58** into the shield chamber **35***d* and exits via the discharge port **28** which is directly in communication with the shield chamber **35***d*.

This flow path defined by the muffler wall **42**, divider walls **52**, **54**, **56**, shield wall **58**, and their respective openings, acts to reduce the turbulence and pulsations in the discharge flow, thereby reducing the noise and vibration of the compressor. The openings **44***a*, **44***b*, **44***c* in muffler wall **42**, as well as opening **59** in shield wall **58**, act as restrictions which regulate the flow from one chamber to the next. While these restrictions do not substantially change the pressure of the fluid or its flow rate, these restrictions do have a dampening effect of reducing the turbulence and pulsations in the fluid flow. It will be recognized that the efflciency of the compressor is increased (i.e. lower power consumption) due to streamlined flow with less turbulence. Preferably, openings **44***a* and **44***c* are notches in an upper end of the muffler wall **42**, and are generally smaller than the larger opening **44***b*, which is also a notch in the muffler wall **42**. Preferably, opening **59** is also a large notch formed in the shield wall **58**.

The first and second portions **35***a*, **35***b* of the discharge chamber **35** are in fluid communication only through the muffler chamber **45**. The restrictions are sized to reduce the turbulence of the fluid flow. Similarly, the third portion **35***c* and second portion **35***b* of the discharge chamber **35** are not in direct fluid communication. The restrictions attenuate the turbulence of the fluid flow from the first and third portions **35***a*, **35***c* of the discharge chamber to the second portion **35***b* of the discharge chamber **35**.

It will also be recognized that the compressor and one or two piston cylinders **17** directly provide high pressure fluid to the second portion **35***b* of the discharge chamber, which is proximate the discharge port **28**. When the shield wall **58** is employed as shown, one discharge opening **19** provides high pressure fluid directly to the shield chamber **35***d* which is in direct fluid communication with the discharge port **28**. Thus, the supply of high pressure fluid is not delayed or compromised by the muffler **40** of the present invention.

Accordingly, it will be recognized by those skilled in the art that the present invention provides a muffler which is integrally incorporated into the rear housing of a compressor. In this way, the muffler reduces the overall size, weight and cost of the compressor. Additionally, the integral muffler adds stiffness to the rear housing that attributes to lower vibration. Furthermore, additional machining operations are not required as the muffler can be cast directly into the rear housing. Finally, the refrigerant flow is directed through the discharge chamber and muffler in such a way as to fully utilize the volume effectively to reduce flow turbulence, while not causing any significant flow loss or delay in fluid supply. In turn, the efficiency of the compressor is increased (i.e. lower power consumption) due to streamlined flow with less turbulence.

The foregoing description of various embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise embodiments disclosed. Numerous modifications or variations are possible in light of the above teachings. The embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

What is claimed is:

1. A rear housing for a compressor, the compressor having a cylinder block receiving low pressure fluid from the rear housing via a plurality of suction openings, the cylinder block providing high pressure fluid to the rear housing via a plurality of discharge openings, the rear housing comprising:

an annular inner wall;

an annular muffler wall circumscribed by the inner wall, the muffler wall defining a muffler chamber;

a discharge chamber defined between the muffler wall and the inner wall, the discharge chamber in fluid communication with a discharge port for transmitting high pressure fluid;

a first divider wall and a second divider wall extending between the muffler wall and the inner wall, the first and second divider walls being spaced apart to define first and second portions of the discharge chamber, the second portion of the discharge chamber communicating with the discharge port; and

the muffler wall defining a first restriction between the first portion of the discharge chamber and the muffler chamber, the muffler wall defining a second restriction between the second portion of the discharge chamber and the muffler chamber, the restrictions attenuating the turbulence of the fluid flow from the first portion to the second portion through the muffler chamber.

2. The rear housing of claim **1**, wherein the first and second restrictions are formed by openings in the muffler wall.

3. The rear housing of claim **2**, wherein the openings are notches formed into the muffler wall.

4. The rear housing of claim **1**, further comprising shield wall positioned within the second portion of the discharge chamber to define a shield chamber fluidically connected to the discharge port, the shield wall defining a shield restriction between the second portion of the discharge chamber and the shield chamber.

5. The rear housing of claim **1**, further comprising a third divider wall extending between the muffler wall and the inner wall to define a third portion of the discharge chamber, the muffler wall defining a third restriction between the third portion of the discharge chamber to the muffler chamber.

6. The rear housing of claim **1**, wherein at least one of the plurality of discharge openings provides high pressure fluid directly to the second portion of the discharge chamber.

7. A muffler for a compressor, the compressor including a housing having a rear housing defining an end of the housing, the rear housing including an annular outer wall circumscribing an annular inner wall to define a suction chamber and a discharge chamber, the suction chamber fluidically connected to a suction port and a plurality of suction openings for intake of low pressure fluid, the discharge chamber fluidically connected to a discharge port and a plurality of discharge openings for output of high pressure fluid, the muffler comprising:

an annular muffler wall formed into the rear housing to define a muffler chamber positioned within the discharge chamber;

a first divider wall and a second divider wall extending between the muffler wall and the inner wall, the first and second divider walls being spaced apart to define first and second portions of the discharge chamber, the second portion of the discharge chamber being fluidically connected to the discharge port; and

the muffler wall defining a first opening and a second opening, the first opening fluidically connecting the first portion of the discharge chamber to the muffler chamber, the second opening fluidically connecting the second portion of the discharge chamber to the muffler chamber.

8. The muffler of claim **7**, wherein the muffler wall is positioned between the first portion of the discharge chamber and the muffler chamber, and wherein the muffler wall is positioned between the second portion of the discharge chamber and the muffler chamber.

9. The muffler of claim **7**, wherein the discharge chamber is completely circumscribed by the suction chamber.

10. The muffler of claim **7**, wherein the first and second portions of the discharge chamber are in fluid communication only through the muffler chamber.

11. The muffler of claim **7**, wherein the muffler wall and first opening form a first restriction, and wherein the muffler wall and second opening form a second restriction, the first and second restrictions regulating the fluid flow from the first portion of the discharge chamber to the second portion of the discharge chamber.

12. The muffler of claim **11**, wherein the first and second restrictions are sized to reduce the turbulence of the fluid flow.

13. The muffler of claim **7**, wherein at least one of the plurality of discharge openings provides high pressure fluid directly to the second portion of the discharge chamber.

14. The muffler of claim **7**, further comprising a third divider wall extending between the muffler wall and the inner wall to define a third portion of the discharge chamber, the muffler wall including a third opening fluidically connecting the third portion of the discharge chamber to the muffler chamber.

15. The muffler of claim **14**, wherein the second and third portions of the discharge chamber are not in direct fluid communication.

16. The muffler of claim **7**, further comprising shield wall positioned within the second portion of the discharge chamber to define a shield chamber, the shield wall including a shield opening fluidically connecting the second portion of the discharge chamber to the shield chamber, the shield chamber being fluidically connected to the discharge port.

17. A muffler for a compressor, the compressor including a housing having a rear housing defining an end of the housing, the rear housing including an annular outer wall circumscribing an annular inner wall to define a suction chamber and a discharge chamber, the suction chamber fluidically connected to a suction port and a plurality of suction openings for intake of low pressure fluid, the discharge chamber fluidically connected to a discharge port and a plurality of discharge openings for output of high pressure fluid, the muffler comprising:

an annular muffler wall formed into the rear housing to define a muffler chamber within the discharge chamber;

a first divider wall and a second divider wall extending between the muffler wall and the inner wall, the first and second divider walls being spaced apart to define first and second portions of the discharge chamber, the second portion of the discharge chamber being fluidically connected to the discharge port;

the first and second portions of the discharge chamber being in fluid communication only through the muffler chamber; and

at least one of the plurality of discharge openings providing high pressure fluid directly to the second portion of the discharge chamber.

18. The muffler of claim **17**, wherein at least one of the plurality of discharge openings provides high pressure fluid to the first portion of the discharge chamber for passage through the muffler chamber and second portion of the discharge chamber for exit via the discharge port.

19. The muffler of claim **17**, wherein the muffler wall defines a first restriction and a second restriction, the first restriction regulating the fluid flow from the first portion of the discharge chamber to the muffler chamber, the second restriction regulating the fluid flow from the second portion of the discharge chamber to the muffler chamber.

20. The muffler of claim **17**, further comprising shield wall positioned within the second portion of the discharge chamber to define a shield chamber, the shield wall including a shield restriction fluidically connecting the second portion of the discharge chamber to the shield chamber, the shield chamber being fluidically connected to the discharge port.

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