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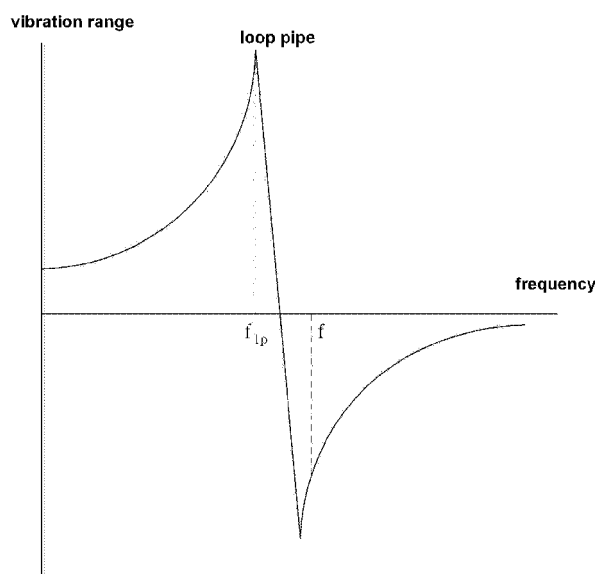
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(54) **LINEAR COMPRESSOR**

(57) The present invention discloses a linear compressor including: a hermetic container which defines a sealed space where a refrigerant flows in and out and which has an inlet pipe and an outlet pipe; a cylinder provided in the hermetic container and having a compression space therein; a piston linearly reciprocated in the cylinder and compressing the refrigerant of the compression space; a linear motor supplying a driving force to the piston and operating the piston at a set operating frequency; a plurality of support springs elastically sup-

porting an assembly composed of the cylinder, the piston and the linear motor on the bottom surface of the hermetic container; and a loop pipe provided to guide the refrigerant compressed in the compression space to the outlet pipe. As the exciting force exerted on the hermetic container by the loop pipe has an opposite phase to the exciting force exerted on the hermetic container by the support springs, vibration of the assembly can be offset by vibration of the loop pipe through the phase shift, and thus the overall vibration can be reduced.

Figure 4



Description

Technical Field

[0001] The present invention relates to a linear compressor which can reduce vibration through the phase shift between vibration factors.

Background Art

[0002] In general, a compressor is a mechanical apparatus for receiving power from a power generation apparatus, such as an electric motor, a turbine, etc. and compressing the air, refrigerant or other various operating gases to raise the pressure. The compressor has been widely used in electric home appliances such as refrigerators, air conditioners, etc., and its application has been expanded to the whole industry.

[0003] The compressors are roughly classified into a reciprocating compressor in which a compression space for sucking and discharging an operating gas is defined between a piston and a cylinder so that the piston can be linearly reciprocated in the cylinder to compress a refrigerant, a rotary compressor in which a compression space for sucking and discharging an operating gas is defined between an eccentrically-rotated roller and a cylinder so that the roller can be eccentrically rotated along the inner wall of the cylinder to compress a refrigerant, and a scroll compressor in which a compression space for sucking and discharging an operating gas is defined between an orbiting scroll and a fixed scroll so that the orbiting scroll can be rotated along the fixed scroll to compress a refrigerant.

[0004] Recently, a linear compressor which not only improves compression efficiency but also has a simple structure has been actively developed among the reciprocating compressors. In particular, the linear compressor does not have a mechanical loss caused by motion conversion since a piston is directly connected to a driving motor which performs a linear reciprocating motion.

[0005] FIG. 1 is a structural diagram of vibration factors of a conventional linear compressor.

[0006] As illustrated in FIG. 1, the conventional linear compressor includes a hermetic container 10 defining a sealed space and a main body 20 composed of a cylinder, a piston and a linear motor and compressing a refrigerant in the hermetic container 10. Here, the main body 20 is elastically supported in the hermetic container 10 by a plurality of support springs S and a loop pipe L defining a discharge passage of the refrigerant, and the hermetic container 10 is fixed to and elastically supported on the installation surface via a mount 11 provided on its bottom surface.

[0007] Normally, in the linear compressor, a permanent magnet of the linear motor driving the piston is driven together with the piston, which increases the vibration as well as the mass of a mechanism unit performing a linear reciprocating motion. However, since the linear compres-

sor operates in a resonance state to improve compression efficiency, reducing the mass of the mechanism unit to reduce vibration may unsuitably degrade the overall efficiency of the compressor. Therefore, in the linear compressor, it is necessary to optimize the vibration transferring characteristic between the hermetic container 10 and the main body 20 so as to reduce vibration. Here, the factors having an influence on the vibration transferring characteristic include the mount 11, the support springs S, and the loop pipe L. While the rigidity of the mount 11 and the rigidity and height of the support springs S do not have an influence on the overall efficiency, a given rigidity and mass of the loop pipe L have a large influence on the overall efficiency in terms of the design of the linear compressor using the resonance.

[0008] FIG. 2 is a graph showing vibration displacements of the loop pipe employed in the conventional linear compressor.

[0009] As illustrated in FIG. 2, the design is made such that the conventional linear compressor has a rated operating frequency of 60 Hz and that the loop pipe has a natural frequency of 70 Hz to 90 Hz which is higher than the rated operating frequency. Here, as in the conventional reciprocating compressor, the linear motor raises the operating frequency from 0 Hz to 60 Hz upon starting. Specifically, if the natural frequency of the loop pipe is lower than the operating frequency of the linear compressor, while the operating frequency of the linear compressor is raised to the rated operating frequency upon starting, resonance occurs when the operating frequency of the linear compressor becomes equal to the natural frequency of the loop pipe, which may lead to damage of the loop pipe. It is thus preferable that the natural frequency of the loop pipe should be set higher than the rated operating frequency of the linear compressor.

[0010] However, in the conventional linear compressor, the main body is elastically supported in the hermetic container by the support springs and the loop pipe, and the natural frequency of the loop pipe is set higher than the rated operating frequency. While the operating frequency is raised to the rated operating frequency upon starting, the exciting force of the loop pipe increases in the same direction as the exciting force of the support springs. As a result, the exciting force of the loop pipe and the exciting force of the support springs are superimposed, which amplifies vibration transferred to the entire compressor upon starting.

Disclosure

Technical Problem

[0011] The present invention has been made to solve the aforementioned problems in the prior art. An object of the present invention is to provide a linear compressor which can reduce vibration through the phase shift.

Technical Solution

[0012] According to an aspect of the present invention for achieving the above object, there is provided a linear compressor including: a hermetic container which defines a sealed space where a refrigerant flows in and out and which has an inlet pipe and an outlet pipe; a cylinder provided in the hermetic container and having a compression space therein; a piston linearly reciprocated in the cylinder and compressing the refrigerant of the compression space; a linear motor supplying a driving force to the piston and operating the piston at a set operating frequency; a plurality of support springs elastically supporting an assembly composed of the cylinder, the piston and the linear motor on the bottom surface of the hermetic container; and a loop pipe provided to guide the refrigerant compressed in the compression space to the outlet pipe, wherein the exciting force exerted on the hermetic container by the loop pipe has an opposite phase to the exciting force exerted on the hermetic container by the support springs.

[0013] In addition, the natural frequency of the loop pipe may be set equal to or lower than the rated operating frequency of the linear motor.

[0014] Moreover, the rated operating frequency of the linear motor may be set to 60 Hz, and the natural frequency of the loop pipe may be set to 50 Hz or less.

[0015] According to another aspect of the present invention, there is provided a linear compressor including: a hermetic container which defines a sealed space where a refrigerant flows in and out; a cylinder provided in the hermetic container and having a compression space therein; a piston linearly reciprocated in the cylinder and compressing the refrigerant of the compression space; a linear motor supplying a driving force to the piston and operating the piston at a set operating frequency; a support spring elastically supporting an assembly composed of the cylinder, the piston and the linear motor on the bottom surface of the hermetic container; and a loop pipe provided to guide the refrigerant compressed in the compression space to the outlet pipe, wherein the rated operating frequency of the linear motor is greater than the natural frequency of the loop pipe.

[0016] Additionally, the rated operating frequency of the linear motor may be determined in proportion to the natural frequency of the loop pipe.

Advantageous Effects

[0017] As described above, in the linear compressor according to the present invention, the main body is elastically supported in the hermetic container by the support springs and the loop pipe, and the natural frequency of the loop pipe is set lower than the rated operating frequency. Since the linear compressor operates at the rated operating frequency directly upon starting by using the inverter motor, the exciting force of the loop pipe moves in the opposite direction to the exciting force of

the support springs at the rated operating frequency, thereby reducing vibration transferred to the entire compressor.

Description of Drawings

[0018]

FIG. 1 is a structural diagram of vibration factors of a conventional linear compressor.

FIG. 2 is a graph showing vibration displacements of a loop pipe employed in the conventional linear compressor.

FIG. 3 is a side-sectional view of an embodiment of a linear compressor according to the present invention.

FIG. 4 is a graph showing vibration displacements of a loop pipe employed in the linear compressor according to the present invention.

FIG. 5 is a graph showing vibration amplitudes of a hermetic container by variations of the natural frequency of the loop pipe in the linear compressor according to the present invention.

Mode for Invention

[0019] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the attached drawings.

[0020] FIG. 3 is a side-sectional view of an embodiment of a linear compressor according to the present invention.

[0021] Referring to FIG. 3, in the embodiment of the linear compressor according to the present invention, a cylinder 200, a piston 300, and a linear motor 400 composed of an inner stator 420, an outer stator 440 and a permanent magnet 460 are provided in a hermetic container 110 defining a sealed space. When the permanent magnet 460 is linearly reciprocated between the inner stator 420 and the outer stator 440 due to a mutual electromagnetic force, the piston 300 connected to the permanent magnet 460 is linearly reciprocated together with the permanent magnet 460.

[0022] While the inner stator 420 is secured to the outer circumference of the cylinder 200, the outer stator 440 is secured in the axial direction by a frame 520 and a motor cover 540. The frame 520 and the motor cover 540 are coupled to each other by means of a fastening member such as a bolt, so that the outer stator 440 is secured between the frame 520 and the motor cover 540. The frame 520 may be integrated with the cylinder 200 or may be separately manufactured and coupled to the cylinder 200. In the embodiment shown in FIG. 3, the frame 520 and the cylinder 200 are provided as an integral unit.

[0023] A supporter 320 is connected to the rear of the piston 300. Both ends of four front main springs 800 are supported by the supporter 320 and the motor cover 540. In addition, both ends of four rear main springs 800 are

supported by the supporter 320 and a back cover 560 that is coupled to the rear of the motor cover 540. Moreover, a suction muffler 700 is provided at the rear of the piston 300 and reduces noise when a refrigerant flows into the piston 300.

[0024] The piston 300 is provided as a hollow type so that the refrigerant flowing through the suction muffler 700 can be introduced into and compressed in a compression space P defined between the cylinder 200 and the piston 300. A suction valve 610, which is provided at a front end of the piston 300, opens the front end of the piston 300 to allow the refrigerant to flow from the piston 300 to the compression space P and closes it to prevent the refrigerant from flowing backward from the compression space P to the piston 300.

[0025] If the refrigerant is compressed in the compression space P over a given pressure by the piston 300, it opens a discharge valve 620 positioned at a front end of the cylinder 200. The discharge valve 620 is provided in a support cap 640 secured to one end of the cylinder 200 and is elastically supported by a spiral discharge valve spring 630. The compressed high-pressure refrigerant is discharged to a discharge cap 660 through a hole formed in the support cap 640, discharged to the outside of the linear compressor 100 through a loop pipe L, and circulated in a refrigeration cycle.

[0026] The respective components of the linear compressor 100 described above are supported by a front support spring 120 and a rear support spring 140 in the assembled state and spaced apart from the bottom of the hermetic container 110. Since the components are not in direct contact with the bottom of the hermetic container 110, vibration generated in the respective components of the linear compressor 100 while they are compressing the refrigerant is not directly transferred to the hermetic container 110. As a result, it is possible to reduce vibration transferred to the outside of the hermetic container 110 and noise caused by the vibration of the hermetic container 110.

[0027] As described in connection with the prior art, it is necessary for the linear compressor to optimize the vibration transferring characteristic so as to reduce vibration and also necessary to place a limitation on the design of the loop pipe L which is a factor having an influence on compression efficiency. Of course, as the main body composed of the cylinder 200, the piston 300 and the linear motor 400 is elastically supported in the hermetic container 110 by the support springs 120 and 140 and the loop pipe L, vibration transferred to the hermetic container 110 can be considered as the sum of the exciting force of the support springs 120 and 140 and the exciting force of the loop pipe L. However, according to the present invention, the design is made such that the exciting force of the loop pipe L has the opposite phase to the exciting force of the support springs 120 and 140, thus reducing vibration transferred to the entire compressor.

[0028] FIG. 4 is a graph showing vibration displace-

ments of the loop pipe employed in the linear compressor according to the present invention.

[0029] Referring to FIG. 4, in the linear compressor according to the present invention, the natural frequency f_{lp} of the loop pipe is set lower than the rated operating frequency f so as to reduce vibration through the phase shift. Here, as shown in the graph, while the loop pipe vibrates in a positive(+) direction at a frequency lower than its natural frequency f_{lp} , it vibrates in a negative(-) direction at a frequency higher than its natural frequency f_{lp} . Therefore, if the rated operating frequency f is higher than the natural frequency f_{lp} of the loop pipe, vibration of the loop pipe is phase-shifted, and the exciting force of the loop pipe operates in the opposite direction to the exciting force of the support springs, which reduces vibration transferred to the entire hermetic container.

[0030] Further, the linear motor operates at the rated operating frequency f directly upon starting in order to prevent damage of the loop pipe. At this time, if the linear motor sweeps from 0 to the rated operating frequency f upon starting, the operating frequency becomes equal to the natural frequency f_{lp} of the loop pipe before reaching to the rated operating frequency f , which leads to resonance damaging the loop pipe. It is thus preferable to employ an inverter motor, which operates at the rated operating frequency f directly upon starting, as the linear motor.

[0031] For example, the rated operating frequency f may be set to 60 Hz so that the linear motor operates at the rated operating frequency f directly upon starting, and the natural frequency f_{lp} of the loop pipe may be set to 50 Hz or less which is lower than the rated operating frequency f .

[0032] FIG. 5 is a graph showing vibration amplitudes of the hermetic container by variations of the natural frequency of the loop pipe in the linear compressor according to the present invention.

[0033] FIG. 5 shows an experiment result of the linear compressor according to the present invention, in which experiment the vibration transferred to the entire hermetic container was measured, setting the rated operating frequency to 60 Hz and varying the natural frequency of the loop pipe.

[0034] As shown in FIG. 5, the closer the natural frequency f_{lp} of the loop pipe to 60 Hz which is the rated operating frequency, the greater the vibration transferred to the entire hermetic container. When the natural frequency f_{lp} of the loop pipe is set in a frequency domain lower than 60 Hz which is the rated operating frequency f , it reduces vibration transferred to the entire hermetic container.

[0035] In more detail, if the natural frequency f_{lp} of the loop pipe varies from 35 Hz to 50 Hz, vibration of the hermetic container increases from 13 Gal to 75 Gal. However, since a vibration variation Δf of the hermetic container caused by a natural frequency variation Δf_{lp} of the loop pipe is small, it can be deemed that vibration transferred to the compressor is stable in this section. Mean-

while, if the natural frequency f_{lp} of the loop pipe varies from 50 Hz to 60 Hz, vibration of the hermetic container increases from 57 Gal to 1120 Gal. As the vibration variation Δf of the hermetic container caused by the natural frequency variation Δf_{lp} of the loop pipe is large, it can be deemed that vibration transferred to the compressor is amplified in this section. Additionally, if the natural frequency f_{lp} of the loop pipe varies from 60 Hz to 70 Hz, vibration of the hermetic container decreases from 1120 Gal to 452 Gal. But, since the vibration variation Δf of the hermetic container caused by the natural frequency variation Δf_{lp} of the loop pipe is smaller than that in the above variation amplification section, even if the actual vibration value transferred to the hermetic container decreases, it is much larger than in the above vibration stable section. Furthermore, if the natural frequency f_{lp} of the loop pipe varies to 70 Hz or more, vibration of the hermetic container decreases to 452 Gal or less. However, since the vibration variation Δf of the hermetic container caused by the natural frequency variation Δf_{lp} of the loop pipe is smaller than that in the above variation amplification section, likewise, even if the actual vibration value transferred to the hermetic container decreases, it is much larger than in the above vibration stable section.

[0036] As a result, taking vibration of the entire compressor into consideration, it is preferable that the natural frequency f_{lp} of the loop pipe should be set in a frequency domain of 50 Hz or less in the compressor having a rated operating frequency f of 60 Hz. Moreover, considering that the natural frequency f_{lp} of the loop pipe is determined in proportion to the rated operating frequency f , it is preferable that the natural frequency f_{lp} of the loop pipe should be set in a frequency domain of 41.6 Hz or less in the compressor having a rated operating frequency f of 50 Hz.

[0037] The present invention has been described in detail with reference to the exemplary embodiments and the attached drawings. However, the scope of the present invention is not limited to such embodiments and drawings, but is defined by the appended claims.

Claims

1. A linear compressor, comprising:

a hermetic container which defines a sealed space where a refrigerant flows in and out and which has an inlet pipe and an outlet pipe;
a cylinder provided in the hermetic container and having a compression space therein;
a piston linearly reciprocated in the cylinder and compressing the refrigerant of the compression space;
a linear motor supplying a driving force to the piston and operating the piston at a set operating frequency;
a plurality of support springs elastically support-

ing an assembly composed of the cylinder, the piston and the linear motor on the bottom surface of the hermetic container; and
a loop pipe provided to guide the refrigerant compressed in the compression space to the outlet pipe,
wherein the exciting force exerted on the hermetic container by the loop pipe has an opposite phase to the exciting force exerted on the hermetic container by the support springs.

2. The linear compressor of Claim 1, wherein the natural frequency of the loop pipe is set equal to or lower than the rated operating frequency of the linear motor.

3. The linear compressor of Claim 2, wherein the rated operating frequency of the linear motor is set to 60 Hz, and the natural frequency of the loop pipe is set to 50 Hz or less.

4. A linear compressor, comprising:

a hermetic container which defines a sealed space where a refrigerant flows in and out;
a cylinder provided in the hermetic container and having a compression space therein;
a piston linearly reciprocated in the cylinder and compressing the refrigerant of the compression space;
a linear motor supplying a driving force to the piston and operating the piston at a set operating frequency;
a support spring elastically supporting an assembly composed of the cylinder, the piston and the linear motor on the bottom surface of the hermetic container; and
a loop pipe provided to guide the refrigerant compressed in the compression space to the outlet pipe,
wherein the rated operating frequency of the linear motor is greater than the natural frequency of the loop pipe.

5. The linear compressor of Claim 4, wherein the rated operating frequency of the linear motor is determined in proportion to the natural frequency of the loop pipe.

Figure 1

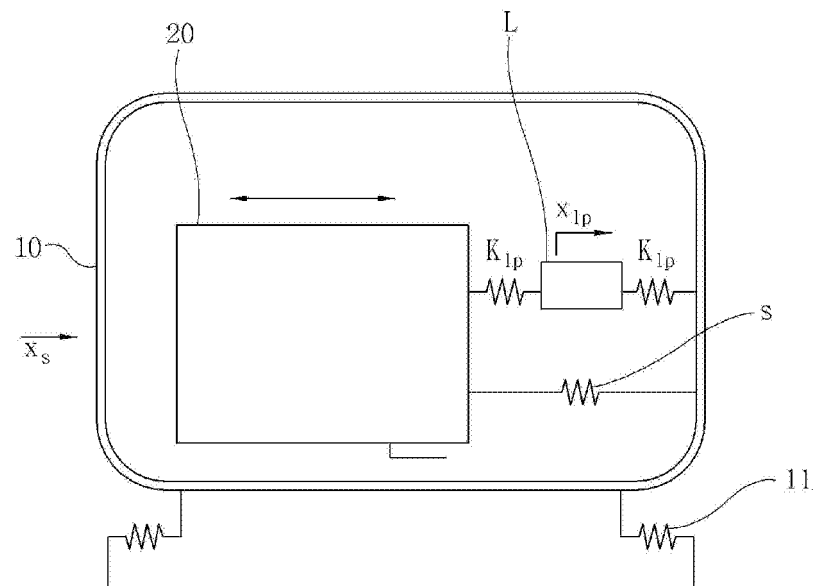


Figure 2

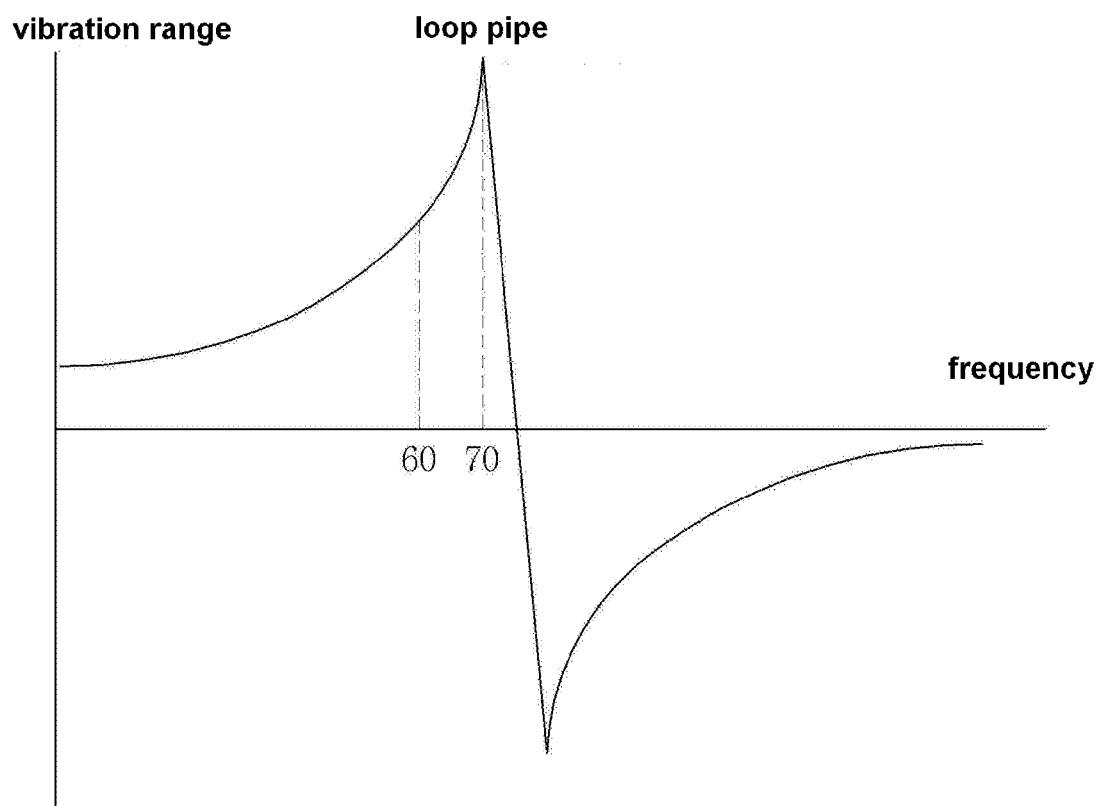


Figure 3

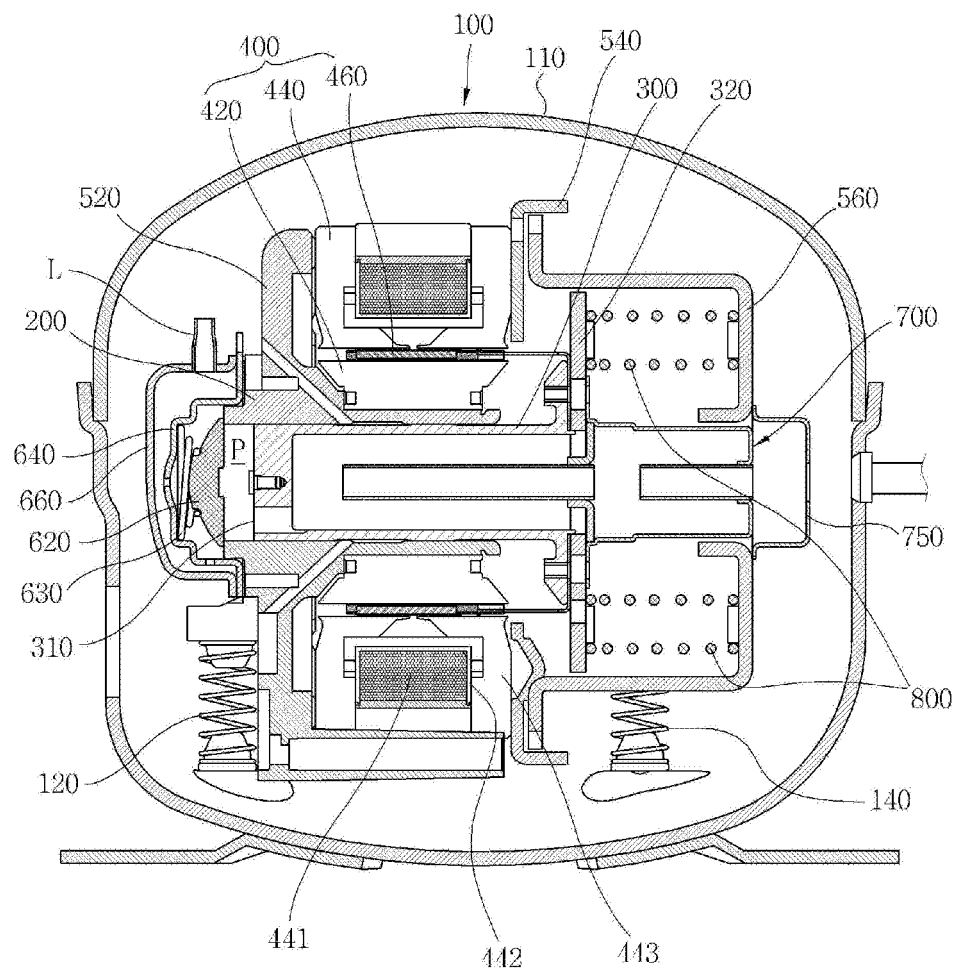


Figure 4

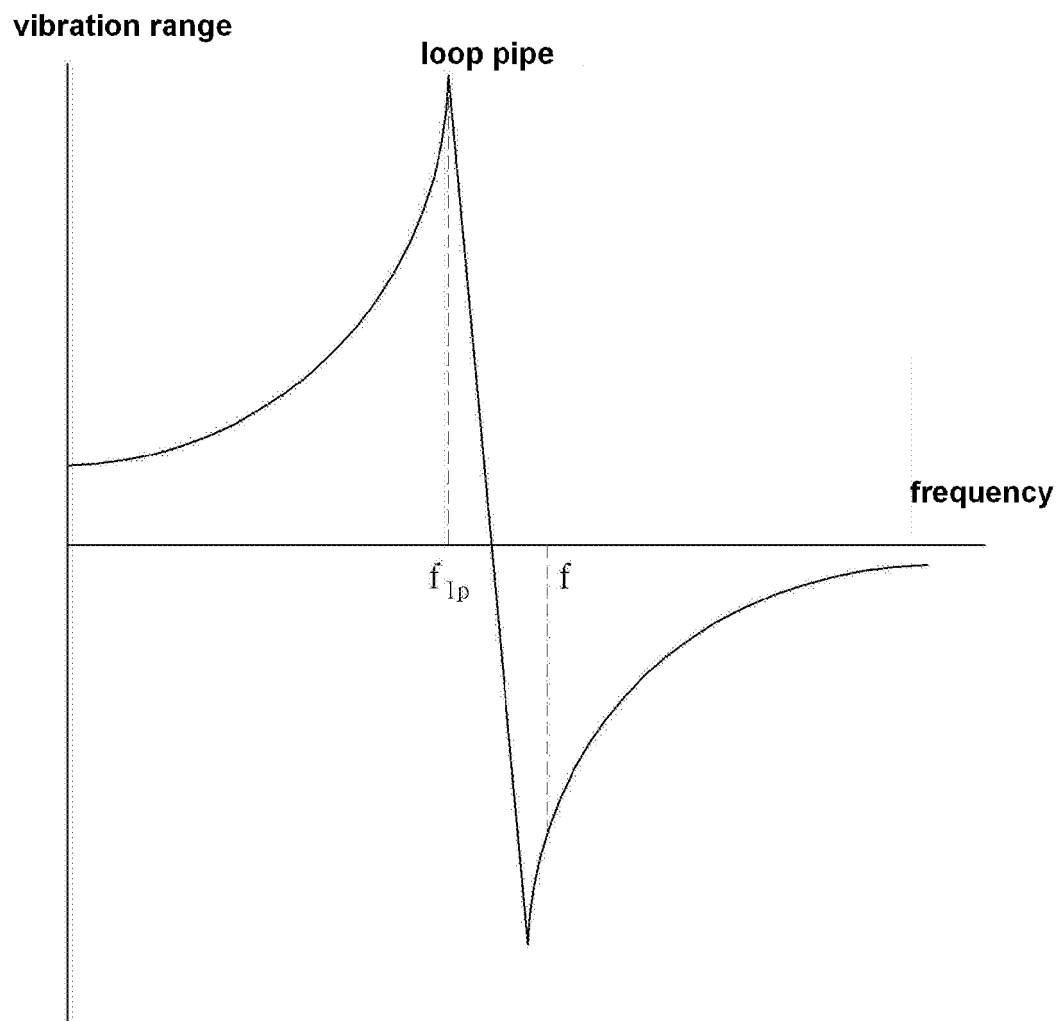


Figure 5

