SUSPENSION FOR LINEAR COMPRESSOR

ABSTRACT

A refrigeration system compressor including a hermetic housing and a linear compressor within said hermetic housing. The compressor includes at least two relatively reciprocating parts, with one part typically being much greater mass than the other part. The relative reciprocation of the centre of mass of each part occurs along an axis of reciprocation. The compressor hangs from a pair of suspension elements. Each suspension element includes a first attachment portion connected to the compressor and a second attachment portion connected to an upper support point above the compressor. A body spans between the first attachment portion and the second attachment portion. The body comprises a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of the compressor.
SUSPENSION FOR LINEAR COMPRESSOR

FIELD OF THE INVENTION

[0001] The present invention relates to linear compressors, and in particular linear compressors of the type suitable for use in a vapour compression refrigeration system.

BACKGROUND TO THE INVENTION

[0002] Linear compressors of a type for use in a vapour compression refrigeration system are the subject of many documents in the prior art. One such document is our co-pending PCT patent application PCT/NZ2004/000108. That specification describes a variety of developments relating to compressors, many of which have particular application to linear compressors. The present invention relates to further improvements to compressor embodiments such as are described in that patent application, which provides a general description of an example compressor to which the present invention may be applied. However the present invention may also be applied beyond the scope of the particular embodiments of linear compressor disclosed in that application. Persons skilled in the art will appreciate the general application of the ideas herein to other embodiments of linear compressors such as are found in the prior art.

[0003] The present invention relates generally to suspension elements for suspending the compressor assembly within the hermetic shell. PCT/NZ2004/000108 describes several suspension arrangements using coil springs.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide a suspension element with improved characteristics with particular application to linear compressors and/or to provide refrigeration compressors incorporating such suspension elements, or to at least provide the industry with a useful choice.

[0005] In a first aspect the invention consists in a suspension element supporting a linear compressor within a hermetic shell, said suspension element comprising:

[0006] a first attachment portion connected to the compressor, a second attachment portion connected to an upper support point above the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of said compressor.

[0007] In a further aspect the present invention consists in a refrigeration system compressor comprising a hermetic housing, a linear compressor within said hermetic housing, said compressor including at least two relatively reciprocating parts, with one part typically being much greater mass than the other part, the relative reciprocation of the centre of mass of each part occurring along an axis of reciprocation, and

[0008] a first suspension element comprising:

[0009] a first attachment portion connected to the compressor, a second attachment portion connected to an upper support point above the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of said compressor.

[0010] and a second suspension element comprising:

[0011] a first attachment portion connected to the compressor, a second attachment portion connected to an upper support point above the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of said compressor.

[0012] the first attachment portion of each said suspension element being connected with said compressor part of greater mass, and the second attachment portion of each said element being fixed to one part of said hermetic housing, such that substantially the entire weight of said compressor hangs from said second attachment portions.

[0013] To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a side elevation in cross-section of a refrigeration compressor including a linear compressor suspended in a housing. The compressor is suspended in the housing at each end by a suspension element according to a preferred embodiment of the present invention.

[0015] FIG. 2 is a perspective view of a suspension element according to a first embodiment of the present invention.

[0016] FIG. 3 is a side elevation, with partial cutaway, showing a pair of suspension elements as illustrated in FIG. 2 assembled together.

[0017] FIG. 4 is a side elevation of a suspension assembly for one end of the compressor, including a pair of suspension elements assembled together, a clamp for clamping the elements to the compressor and locating components for securing the suspension elements within the compressor housing. The locating components and clamp are shown in cross-section through the centre line of the compressor. The suspension elements are shown in partial cutaway.

[0018] FIG. 5 is a perspective view of the clamp illustrated in the assembly of FIG. 4.

[0019] FIG. 6 is a perspective view of a locating component in accordance with the assembly of FIG. 4.

DETAILED DESCRIPTION

[0020] Referring to FIG. 1, the compressor for a vapour compression refrigeration system includes a linear compressor 1 supported inside a housing 2. Typically the housing 2 is hermetically sealed and includes a gases inlet port 3 and a compressed gases outlet port 4. Uncompressed gases flow within the interior of the housing surrounding the compressor 1. These uncompressed gases are drawn into the compressor during intake stroke, compressed between the piston
crown 14 and valve plate 5 on the compression stroke, and expelled through discharge valve 6 into a compressed gases manifold 7. Compressed gases exit the manifold 7 to the outlet port 4 in the shell through a flexible tube 8. To reduce the stiffness of discharge tube 8 the tube is preferably arranged as a loop or spiral transverse to the reciprocating axis of the compressor. The intake to the compression space may be through the piston (with an aperture and valve in the crown) or through the head, divided to include suction and discharge manifolds and valves.

[0021] The illustrated linear compressor 1 has, broadly speaking, a cylinder part and a piston part connected by a main spring. The cylinder part includes cylinder chassis 10, cylinder head 11, valve plate 5 and a cylinder liner 12. It also includes stator parts 15 for a linear electric motor. An end portion 18 of the cylinder part, distal from the head 11, mounts the main spring relative to the cylinder part. In the illustrated embodiment the main spring is a combination of coil spring 19 and flat spring 20.

[0022] The piston part includes a hollow piston 22 with sidewall 24 and crown 14. A rod 26 connects between the crown 14 and a supporting body 30 for linear motor armature 17. The rod 26 has a flexible portion 28 approximately at the centre of the hollow piston 22. The linear motor armature 17 comprises a body of permanent magnet material (such as ferrite or neodymium) magnetised to provide one or more poles directed transverse to the axis of reciprocation of the piston within the cylinder liner. An end portion 32 of armature support 30, distal from the piston 22, is connected with the main spring 19, 20.

[0023] This briefly describes a linear compressor of a type for which the suspension element and arrangement of the present invention is useful. However it will be appreciated that the usefulness of the suspension arrangement of the present invention is not restricted to linear compressors of the type and configuration illustrated. It is generally applicable where operation of the linear compressor results in the relative reciprocation of the centre of mass of the piston carrying part and the centre of mass of the cylinder part along the linear axis.

[0024] The suspension element and arrangement of the present invention is most usefully applied to support the heavier of the relatively moving assemblies, typically the cylinder part assembly. The lighter assembly is supported by the heavier. For example the piston part assembly is supported by the cylinder part assembly. In the preferred embodiment, as illustrated in FIG. 1, a suspension element is provided at each extreme end of the compressor. This is so that the element can have the longest possible span between the housing and the compressor, with connection points to the compressor being the axis of relative reciprocation of the centres of mass of the two main assemblies.

[0025] Referring to FIG. 2, the suspension element of the preferred embodiment of the present invention has a linear or planar flexible element 40 that extends between the compressor housing and the compressor. Essentially the compressor hangs from an upper support bracket, suspended on the linear or planar element 40. In the preferred embodiment the linear or planar flexible element 40 comprises a thin polymer sheet material. This sheet material may encapsulate one or more reinforcing wires or fibres. For example the material of the element may comprise a pair of Mylar plastic sheets laminated together with a reinforcing fibre between them. The reinforcing fibre may for example be an aramid fibre yarn or a narrow gauge multiple strand metallic wire.

[0026] The important qualities of the element 40 are low bending stiffness and low mass.

[0027] In the preferred form of suspension element illustrated in FIG. 2 the flexible element 40 is integrated into an overall component to provide for simplified assembly to the compressor and location within the compressor shell. Each suspension element includes the flexible element 40, fixed at one end into a rigid locating member 42. The locating member 42 may for example be moulded from a plastic material, and preferably is moulded over a rolled edge of the flexible element 40 such that the flexible element 40 is securely fixed within the member 42. The locating member 42 is configured to locate within the refrigeration compressor housing. Preferably the member 42 is to locate in a support component that has been previously secured to the inner surface of the housing. A suitable support component 44 is illustrated in FIG. 6.

[0028] The applicants intend to provide an additional suspension element upwards as illustrated in FIG. 2. The pair of suspension elements allow the compressor to be provided in opposite orientations, such that the same compressor may be fixed on a base platform, or may be inverted and fixed to the ceiling of a machine compartment of a refrigeration.

[0029] For this purpose it is preferred that an assembly comprising a pair of suspension elements may be completed and assembled to the compressor, the compressor may be subsequently fitted into one half of the refrigeration compressor housing, with the other half of the refrigeration compressor housing subsequently secured in place. The suspension element of FIG. 2 is specifically adapted to this purpose. Of course other configurations are possible in which case one or more of the additional features identified below may be omitted.

[0030] In the preferred form of suspension element a support leg 46 extends from one end of the locating member 42. The support leg 46 is substantially parallel with the plane of flexible element 40. The locating member 42 includes at its other end a flange 48. The flange 48 serves to further locate the member 42 in the receptacle 45 of support component 44, and also provides a recess for receiving the free end of the leg 46 of the second suspension element component of the assembly. As illustrated in FIG. 3 a pair of members 42 are thus held in a substantially rigid spaced apart relationship by the pair of legs 46 extending between them. Each flange 48 has a pair of recesses 50, each offset from the plane of the flexible element 40. One recess 50 receives the free end of the leg 46 such that the suspension elements are staggered with the planes of the flexible elements spaced a small distance apart.

[0031] A number of features of the suspension element are provided such that the assembly uses few distinct subcomponents. Of course alternative arrangements are possible, including where the elements comprising the assembly are not identical components. For example a complete component including both flexible elements, rigid locating members and dividing support legs could be manufactured in a
single overmoulding operation, or division of the assembly into two components could be along alternative lines.

[0032] The flexible element 40 of each suspension element preferably includes a pair of divergent flexible members 56. The flexible members 56 may, as illustrated, be spread apart at the ends adjacent the rigid locating member 42 and be together at an attachment portion 54 of the flexible element 40 which allows for securing the flexible element to the suspended compressor. Alternatively, not shown, the flexible members 56 may be together at the locating member for securing to the housing and spread apart at the attachment portion for securing to the compressor.

[0033] Division of the flexible element into two or more narrower strips of flexible material reduces windage and the tendency for the flexible membrane to flap as the compressor reciprocates in the housing. Furthermore the arrangement of strips in connecting between the compressor housing and the compressor may provide stability to the compressor including where the suspension element connects to the compressor at or below the centreline. It should be noted that multiple flexible strips may be provided as individual elements or components, or may be integrated with two or more in the same component or assembly as is the case in the illustrated embodiment.

[0034] The attachment portion 54 of the suspension element preferably comprises a folded end of the flexible element 40. The folded attachment portion 54 may thereby be secured to a suitable attachment bracket or mounting of the compressor assembly by sandwiching between a clamping element and the mounting. Such an arrangement is illustrated in more detail in FIG. 4 where the assembly of a pair of suspension elements is illustrated captured between a pair of support components 44. In the complete compressor the support components 44 are previously secured to the inner surface of the compressor housing.

[0035] Attachment portions 54 are secured to mountings 64 of a mounting bracket 72. The mounting bracket 72 is in turn secured to the compressor, for example as illustrated in FIG. 1. The mountings 64 of mounting bracket 72 each include a seat 66 or 67 respectively to receive the attachment portions 58. The seats 66 and 67 are offset to match the offset between the planes of the flexible elements 40 in the assembly of two suspension elements. The flaps 58 of attachment portions 54 are each secured against the respective seats 66 or 67 by a clamping member 60. The clamping member 60 is tightly fastened to the bracket 62. For example rivets 70 extend through the clamping member 60, the flap 58 of the attachment portion 54 and the mounting 64 and draw all three tightly together.

[0036] In the assembly of two suspension elements, with the planes of flexible elements 40 offset, the clamping bracket 72 may translate relative to support components 44 without the flexible elements interfering with one another. To translate in one direction the attachment portion 54, and respective portions 58 into the open space 74 between the flexible members of the other flexible element. In translating in the other direction the attachment portion of this other flexible element, and its respective mounting, pass into the open space between the flexible members of the first flexible element.

[0037] In arrangements such as those described with reference to FIGS. 3 and 4, where there is a suspension element provided from both above and below the compressor, a degree of slack must be provided so that the elements do not, between them, pull tight as the compressor translates backward and forward in the housing. This degree of slack will set the overall limit of axial translation in the housing. With the compressor mounted in the housing the upper suspension element will be under tension and the slack will be exhibited in the lower suspension element.

[0038] It will be appreciated that arrangements having a flexible flap suspension element extending from both above and below the compressor are only a preferred form of the present invention. The present invention also envisages arrangements in which suspension elements are only provided to hang the compressor from above, in which case the locating portion of the suspension element for connecting to the housing may be adapted to engage with the housing, or with a suitable support component secured to the housing. Alternatively a complete support structure may be included in the single suspension element, including a base member for locating to a lower portion of the housing and a frame extending from the base member to support the upper edge of the flexible element from above the compressor.

[0039] It may be noted that in the suspension elements of the present invention the flexible element is of lightweight and low stiffness in the direction of reciprocation. It will also be noted that in the preferred embodiment each end of the flexible element is secured against rotation, so as to behave as a “built in” end. With the attachment portion 54 secured to the compressor assembly well below the centreline of the compressor assembly, the centre of bending (as defined in our Patent Application PCT/NZ2004/000108) of each suspension element may be in line or at least substantially in line with the axis of the movement of the centre of mass of the compressor assembly, in accordance with one of the inventions disclosed in that application.

[0040] When suspension of the compressor in the housing is by a conventional coil spring there is the disadvantage that when the coil springs are made soft to minimise vibration along the axis of the compressor they allow too much movement at right angles to this axis. This can compromise robustness during transport and handling of the compressors or the appliance in which they are fitted. Conventional coil springs can also be noisy as in use they tend to slide over the snubbers that locate them at each end.

[0041] In preferred applications the compressor runs at a varying natural frequency due to the variable stiffness of the compressed gas associated with the current running conditions. The compressor resonant system allows the compressor to move almost sinusoidally but there are higher order harmonics due mainly to the non linear stiffness of the compressed gas. These higher harmonics can excite resonance in the suspension spring. The spring element of the present invention is very soft in the axis of reciprocation and has little weight of its own. Accordingly the inventors expect that it will not exhibit substantial resonance effects or be a source of noise in the compressor.

1. A suspension element supporting a linear compressor within a hermetic shell, said suspension element comprising:

   a first attachment portion connected to the compressor, a second attachment portion connected to an upper support point above the compressor, and a body spanning
between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of said compressor.

2. A suspension element as claimed in claim 1 wherein said flexible element comprises a thin polymer sheet material.

3. A suspension element as claimed in claim 1 wherein said flexible element comprises a planar fibre reinforced plastic sheet.

4. A suspension element as claimed in claim 1 wherein said first attachment portion is connected to said compressor substantially on or below an axis coinciding with the reciprocating axis of the centre of mass of said compressor.

5. A suspension element as claimed in claim 4 wherein said planar web comprises at least a pair of spokes diverging from said first attachment portion to said second attachment portion.

6. A suspension element as claimed in claim 1 wherein said first attachment portion is a bent or folded portion of said sheet and said bent or folded portion is held in a clamp.

7. A suspension element as claimed in claim 6 wherein said second attachment portion is a bent or folded portion of said sheet, and said bent or folded portion is held in a clamp.

8. A refrigeration system compressor comprising a hermetic housing, a linear compressor within said hermetic housing, said compressor including at least two relatively reciprocating parts, with one part typically being much greater mass than the other part, the relative reciprocation of the centre of mass of each part occurring along an axis of reciprocation, and

a first attachment element comprising:

a first attachment portion connected to the compressor, a second attachment portion connected to an upper support point above the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of said compressor;

and a second attachment element comprising:

a first attachment portion connected to the compressor, a second attachment portion connected to an upper support point above the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element, oriented perpendicular to the axis of reciprocation of said compressor;

the first attachment portion of each said suspension element being connected with said compressor part of greater mass, and the second attachment portion of each said element being fixed to one part of said hermetic housing, such that substantially the entire weight of said compressor hangs from said second attachment portions.

9. A compressor as claimed in claim 8 wherein said flexible element comprises a thin polymer sheet material.

10. A compressor as claimed in claim 8 wherein said flexible element comprises a planar fibre reinforced plastic sheet.

11. A compressor as claimed in claim 8 wherein the second attachment portion of at least one of said first and second suspension elements is connected to said compressor at or below an axis coinciding with the reciprocating axis of the centre of mass of the compressor.

12. A compressor as claimed in claim 11 wherein said body comprises at least a pair of spokes diverging from said first attachment portion to said second attachment portion.

13. A compressor as claimed in claim 11 wherein said compressor includes an inverted suspension element comprising:

a first attachment portion connected to the compressor and a second attachment portion connected to a lower support point below the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element oriented perpendicular to the axis of reciprocation of said compressor.

14. A compressor as claimed in claim 11 wherein said second attachment portion is connected to said compressor below said axis of reciprocation of said centre of mass, and said compressor includes an inverted suspension element comprising:

a first attachment portion connected to the compressor and a second attachment portion connected to a lower support point below the compressor, and a body spanning between said first attachment portion and said second attachment portion, said body comprising a flexible planar or linear element oriented perpendicular to the axis of reciprocation of said compressor.

15. A compressor as claimed in claim 14 wherein said first attachment portion of said inverted suspension element connects to said compressor above said axis coinciding with the reciprocation axis of the centre of mass of said compressor.

16. A compressor as claimed in claim 15 wherein the planar web of one said suspension element comprises at least a pair of spokes diverging from said first attachment portion to said second attachment portion and wherein said first attachment portion of said suspension element is adjacent the gap between said spokes.

17. A compressor as claimed in claim 16 wherein said body of said other suspension element comprises at least a pair of spokes diverging from said first attachment portion to said second attachment portion, and said first attachment portion of said one suspension element is adjacent the gap between spokes of said inverted suspension element.

18. A compressor as claimed in claim 13 including a suspension frame, said second attachment portion of the upper of said suspension elements connected to an upper portion of said frame, and said second attachment portion of the lower of said suspension elements connected to a lower portion of said frame.

19. A compressor as claimed in claim 17 including a suspension frame, said second attachment portion of the upper of said suspension elements connected to an upper portion of said frame, and said second attachment portion of the lower of said suspension elements connected to a lower portion of said frame.

20. A compressor as claimed in claim 16 wherein a compressor mounting for at least one additional suspension element passes through the gap between said spokes of said body.