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(54) ## RECIPROCATING COMPRESSOR FOR USE WITH AN ECONOMIZER

(57) A compressor (20) includes a housing (22) having a suction inlet (24), at least one economizer inlet (25), and an outlet (26). A first cylinder arranged within the housing (22) includes a first suction valve arranged in fluid communication with the suction inlet (24) and a first discharge valve fluidly connected to the outlet (26). At least one second cylinder is arranged within the housing (22). The at least one second cylinder has a second suction valve in fluid communication with the at least one economizer inlet (25) and a second discharge valve fluidly connected to the outlet (26). A first piston (36) is arranged within the first cylinder and a second piston is arranged within the at least one second cylinder.

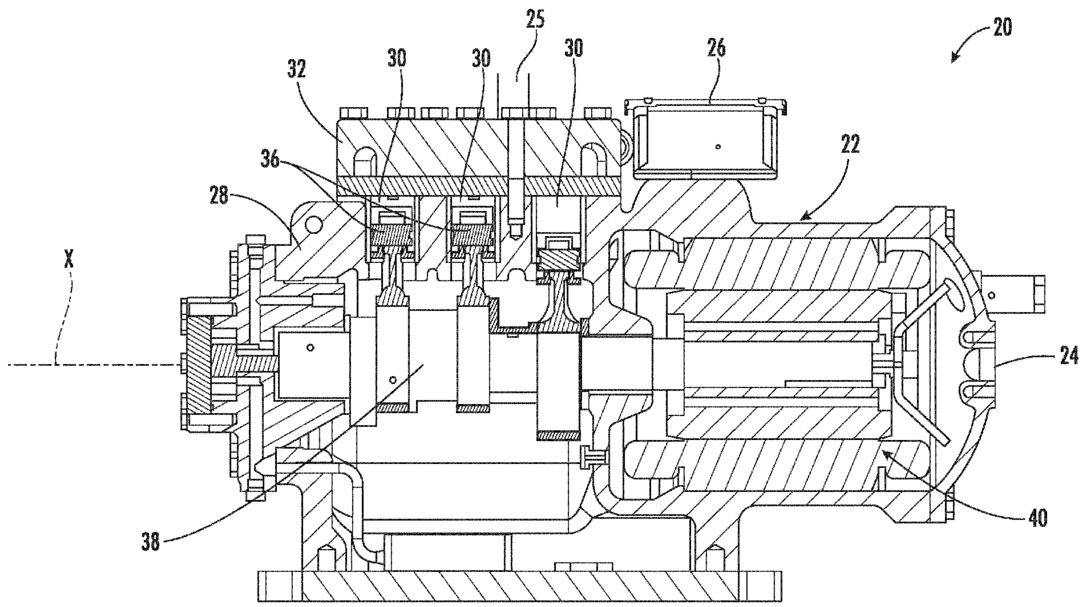

FIG. 1

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Description

[0001] The present invention relates to the art of compressors, and more particularly, to a system and method for compressing a flow from an economizer within a compressor.

[0002] Typically, a multi-stage compressor is used in a vapor compression system including an economizer. A multi-stage compressor includes a first compressor stage and a separate second compressor stage arranged in fluid communication with an outlet of the first compressor stage. In operation, refrigerant compressed within the first compressor stage is discharged from an outlet of the first compressor stage and is delivered to an inlet of the second compressor stage. When used with an economizer, the refrigerant gas from the economizer is typically injected into the conduit connecting the two compressor stages. Accordingly, the refrigerant output from the first compressor stage and the refrigerant from the economizer are compressed together within the second compressor stage. Each compressor stage adds size, complexity, and cost to the compressor.

[0003] According to a first aspect of the invention there is provided a compressor. The compressor includes a housing having a suction inlet, at least one economizer inlet, and an outlet. A first cylinder arranged within the housing includes a first suction valve arranged in fluid communication with the suction inlet and a first discharge valve fluidly connected to the outlet. At least one second cylinder is arranged within the housing. The at least one second cylinder has a second suction valve in fluid communication with the at least one economizer inlet and a second discharge valve fluidly connected to the outlet. A first piston is arranged within the first cylinder and a second piston is arranged within the at least one second cylinder.

[0004] Optionally, the fluid provided at the first discharge valve is configured to bypass the at least one second cylinder.

[0005] Optionally, the first cylinder has a first configuration and the at least one second cylinder has a second configuration, the first configuration and the second configuration being different.

[0006] Optionally, the at least one second cylinder is smaller than the first cylinder.

[0007] Optionally, an amount of compression that occurs within the at least one second cylinder is reduced relative to an amount of compression that occurs within the first cylinder.

[0008] Optionally, a compression ratio of the first cylinder to the at least one second cylinder is between 1:2 and 1:5.

[0009] Optionally, the at least one second cylinder includes a plurality of second cylinders and the at least one economizer inlet includes a plurality of economizer inlets, each of the plurality of second cylinders is arranged in fluid communication with a different one of the plurality of economizer inlets.

[0010] Optionally, at least one of the plurality of second cylinders has a different configuration than another of the plurality of second cylinders.

[0011] According to another aspect of the invention a compressor for use in a vapor compression system is provided. The compressor includes a housing having a suction inlet, an economizer inlet, and an outlet and a plurality of cylinders arranged within the housing. The plurality of cylinders includes a first cylinder configured to receive a first flow of refrigerant from the suction inlet and a second cylinder configured to receive a second flow of refrigerant from the economizer inlet. The second flow of refrigerant is compressed within the plurality of cylinders independently from the first flow of refrigerant.

[0012] Optionally, the first cylinder further includes a first suction valve arranged in fluid communication with the suction inlet and a first discharge valve fluidly connected to the outlet; and the second cylinder further includes a second suction valve in fluid communication with the economizer inlet and a second discharge valve fluidly connected to the outlet.

[0013] Optionally, the first cylinder has a first configuration and the second cylinder has a second configuration, the first configuration and the second configuration being different.

[0014] Optionally, the second cylinder is smaller than the first cylinder.

[0015] Optionally, an amount of compression that occurs within the second cylinder is reduced relative to an amount of compression that occurs within the first cylinder.

[0016] Optionally, a compression ratio of the first cylinder to the at least one second cylinder is between 1:2 and 1:5.

[0017] According to yet another aspect of the invention there is provided a method of operating a compressor. The method includes providing a first flow of refrigerant to a suction inlet of the compressor, compressing the first flow of refrigerant within a first cylinder of the compressor, providing a second flow of refrigerant to an economizer inlet of the compressor, compressing the second flow of refrigerant within a second cylinder of the compressor, and delivering the first flow of refrigerant output from the first cylinder and the second flow of refrigerant output from the second cylinder to an outlet of the compressor.

[0018] Optionally, only the first flow of refrigerant is compressed within the first cylinder, and only the second flow of refrigerant is compressed within the second cylinder.

[0019] Optionally, the first flow of refrigerant output from the first cylinder and the second flow of refrigerant output from the second cylinder are delivered to the outlet independently.

[0020] Optionally, the method comprises mixing the first flow of refrigerant output from the first cylinder and the second flow of refrigerant output from the second cylinder upstream from the outlet.

[0021] Optionally, the first cylinder has a first configuration and the second cylinder has a second configuration that is different from the first configuration.

[0022] Optionally, the method comprises providing a third flow of refrigerant to a second economizer inlet of the compressor and compressing the third flow of refrigerant within another second cylinder of the compressor.

[0023] Certain embodiments of the invention will now be described in greater detail, by way of example only, and with reference to the accompanying drawings, in which:

FIG. 1 is a schematic diagram of an example of a reciprocating compressor;

FIG. 2 is a schematic diagram of an exemplary cylinder of a reciprocating compressor; and

FIG. 3 is a schematic diagram of a plurality of exemplary cylinders of a reciprocating compressor.

[0024] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0025] With reference now to FIG. 1, an example of a compressor 20, more specifically a reciprocating compressor, is illustrated. As shown, the compressor 20 has a housing 22 including a suction port or inlet 24 and a discharge port or outlet 26. The housing 22 includes a cylinder block 28 having one or more bores 30 formed therein, each of which defines a "cylinder" of the compressor 20. In an embodiment, a cylinder head 32 overlies a portion of the cylinder block 28. As best shown in FIG. 2, the cylinder head 32 includes one or more bores 34 corresponding to and aligned with the one or more bores 30 formed in the cylinder block 28.

[0026] Each cylinder 30 is configured to accommodate a piston 36 mounted for reciprocal movement at least partially within a cylinder 30. Examples of multicylinder configurations include, but are not limited to, in-line, V, and horizontally opposed. In the illustrated, non-limiting embodiment, the compressor 20 includes three cylinders 30. However, it should be understood that a compressor 20 having a single cylinder, two cylinders, or more than three cylinders are also contemplated herein.

[0027] The one or more pistons 36 are coupled to a crankshaft 38 mounted within the housing 22. A motor 40 operably coupled to the crankshaft 38 is configured to rotate the crankshaft 38 about an axis of rotation X. Rotation of the crankshaft 38 causes each piston 36 to reciprocate within a respective cylinder 30 within the interior of the cylinder block 28.

[0028] With reference to FIG. 2, a bore 34 formed in the cylinder head 32 may be divided into a plurality of fluidly distinct regions. The regions include a suction region 42 and a discharge region 44. A plurality of valves are disposed at the interface between the bore 34 of the cylinder head 32 and a corresponding, aligned bore 30 within the cylinder block 28. As shown, a suction valve 50 may be associated with the suction region 42 and a discharge valve 52 may be associated with the discharge region 44. In an embodiment, the suction valve 50 and the discharge valve 52 are check valves or no-back valves. However, it should be understood that any suitable type of valve may be used. Accordingly, in an embodiment, one or both of the suction and discharge valves 50, 52 may be actuated in response to a command from a controller C rather than automatically in response to a pressure or flow rate of the refrigerant acting thereon for example.

[0029] As a piston 36 moves downwardly within a respective cylinder 30, a low pressure fluid, such as refrigerant gas for example, is drawn into the cylinder 30. After reaching a bottom of the cylinder 30, or the bottom of the cycle of movement of the piston 36, the piston 36 begins to move upwardly within the cylinder 30. As the piston 36 moves upwardly, the low pressure refrigerant gas within the cylinder 30 is compressed causing the pressure to build within the cylinder 30. This increase in pressure in combination with the movement of the piston 36 causes the high pressure refrigerant gas to flow from the cylinder 30.

[0030] An existing compressor configured for use with a vapor compression system including an economizer or economizing heat exchanger typically includes a first compressor stage having at least one first piston and a second compressor stage having at least one second piston. The flow from the economizer is provided via an economizer inlet to an intermediate region of the compressor arranged between the outlet of the first compressor stage and the inlet of the second compressor stage. As a result, the flow provided from the economizer bypasses the first compression stage and is therefore only compressed within the second compressor stage with the refrigerant flow output from the first compressor stage.

[0031] With reference now to FIG. 3, a portion of a reciprocating compressor for use in a vapor compression system having one or more economizers is illustrated in more detail. In the illustrated, non-limiting embodiment, the compressor 20 includes at least one first cylinder 30a having a first configuration and at least one second cylinder 30b having a second configuration. Similar to the cylinders previously described with respect to FIG. 2, a first piston 36a is movable within the first cylinder 30a and a second piston 36b is movable within the second cylinder 30b, respectively. In addition, a first suction valve 50a and a first discharge valve 52a are arranged between the bore 34a formed in the cylinder head 32 and the first cylinder 30a, and a second suction valve 50b and second discharge valve 52b are arranged between the bore 34b formed in the cylinder head 32 and the second cylinder 30b.

[0032] The at least one first cylinder 30a may be configured to receive a flow of low pressure gaseous refrigerant, such as provided to the compressor 20 from an evaporator located upstream of the compressor 20 within the vapor compression system. The one or more second cylinders 30b may be configured to receive a flow of a medium pressure gaseous refrigerant, such as provided to the compressor 20 from an economizer heat exchanger, also referred to herein as an economizer, of the vapor compression system. Although only a single first cylinder 30a and second cylinder 30b is shown in the FIG., it should be understood that embodiments including any number of first and second cylinders 30a, 30b are contemplated herein. Further, the compressor 20 need not have an identical number of first cylinders 30a and second cylinders 30b.

[0033] In embodiments including a plurality of first cylinders 30a, each of the plurality of first cylinders 30a may have a similar or identical configuration. In embodiments where the compressor 20 includes a plurality of second cylinders 30b, also referred to herein as economizer cylinders, each of the plurality of second cylinders 30b may be configured to receive a flow from the same economizer within the vapor compression system. In such embodiments, each of the plurality of second cylinders 30b may have a similar configuration.

[0034] Alternatively, the plurality of second cylinders 30b may be configured to receive a flow from multiple economizers within the vapor compression system. For example, one second cylinder 30b may be associated with each economizer of the vapor compression system. If the vapor compression system has three separate economizers, each connected to a separate economizer inlet of the compressor 20, the compressor 20 will include at least three second cylinders 30b, one associated with each economizer, respectively. In such embodiments, each of the plurality of second cylinders 30b may be designed based on the respective pressure of the refrigerant provided thereto. Accordingly, the plurality of second cylinders 30b may have similar, or alternatively, may have different configurations.

[0035] The configuration of the one or more first cylinders 30a may be different from the configuration of the one or more second cylinders 30b. In the illustrated, non-limiting embodiment, the one or more second cylinders 30b are smaller than the one or more first cylinders 30a. As a result, less or a smaller amount of compression occurs within the second cylinders 30b than in the first cylinders 30a. In an embodiment, the amount of compression that occurs within the first cylinders 30a may be double or more than double, such as up to five times the amount of compression that occurs within the second cylinders 30b. For example, in an embodiment, the compression ratio of the compression that occurs within the first cylinder 30a relative to the compression that occurs within one of the second cylinders 30b may be anywhere between 1:2 and 1:5. Further, in embodiments where the compressor 20 includes a plurality of second cylinders 30b, it should be understood that the ratio of compression of a first cylinder relative to each of the plurality of second cylinders 30b may vary.

[0036] In embodiments where the compressor 20 has a plurality of inlets arranged in fluid communication with a distinct component of a vapor compression system, each flow of refrigerant provided to one of the plurality of inlets is compressed independently of the other refrigerant flows provided to the other inlets of the compressor 20. For example, in operation, a first flow of refrigerant having a first pressure provided to the main inlet or suction inlet 24 of the compressor 20 is delivered to the one or more first cylinders 30a through the first suction valve 50a. After compression within the at least one first cylinder 30a, the first flow of refrigerant is provided via the first discharge valve 52a to the outlet 26 of the compressor 20 for delivery to a downstream component within the vapor compression system. At the same time, a second flow of refrigerant provided from an economizer and having a second pressure is delivered to a second cylinder 30b via another inlet 25 of the compressor 20, through second suction valve 50b. Within the second cylinder 30b, the second flow of refrigerant is compressed and then output via the second discharge valve 52b. The second flow of refrigerant output from the second cylinder 30b may be delivered to the same outlet 26, or alternatively, to a different outlet as the first flow of refrigerant output from the at least one first cylinder 30a.

[0037] In embodiments where the two distinct flows are provided to the same outlet 26, the compressed first flow of refrigerant output from the first cylinder 30a may be provided to the outlet 26 independently from the compressed second flow of refrigerant output from the second cylinder 30b. However, in other embodiments, the compressed flows may be mixed together upstream from the outlet 26. In such embodiments, the resulting pressure of the flows output from both the at least one first cylinder 30a and the at least one second cylinder 30b may be substantially identical.

[0038] As described herein, only the flow of refrigerant provided to the suction inlet 24 is compressed within the one or more first cylinders 30a and only the flow of refrigerant provided from an economizer to an economizer inlet 25 is compressed within the one or more second cylinders 20b. Therefore, the compressed refrigerant output from any of the cylinders 30a, 30b need not be delivered to another compression stage or cylinder within the compressor 20. In embodiments where the vapor compression cycle includes a second economizer, a third flow of refrigerant output from the second economizer and having a third pressure may be delivered to the compressor 20 via a second economizer inlet (not shown). This third flow of refrigerant may be compressed within another second cylinder of the plurality of second cylinders. However, it should be noted that the another second cylinder is a different second cylinder than the second cylinder used to compressed the flow from the economizer.

[0039] By providing a compressor 20 having a distinct cylinder or stage of cylinders associated with each flow of refrigerant provided to an inlet of the compressor 20, each flow can be compressed within the compressor 20. By using each stage of cylinders to compressor one of the flows, the need for sequential compressing of the refrigerant via multiple stages is eliminated. As a result, the foot print, complexity, and associated cost of the compressor 20 can be reduced.

[0040] The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

[0041] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting to the present invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

[0042] While the present invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present invention as defined by the appended claims. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from the scope of the claims. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed as a mode contemplated for carrying out this present invention, but that the present invention will include all embodiments falling within the scope of the claims.

Claims

1. A compressor (20) comprising:

   a housing (22) having a suction inlet (24), at least one economizer inlet (25), and an outlet (26);
   a first cylinder (30a) arranged within the housing, the first cylinder (30a) having a first suction valve (50a) arranged in fluid communication with the suction inlet (24) and a first discharge valve (52a) fluidly connected to the outlet (26);
   at least one second cylinder (30b) arranged within the housing, the at least one second cylinder (30b) having a second suction valve (50b) in fluid communication with the at least one economizer inlet (25) and a second discharge valve (52b) fluidly connected to the outlet (26); and
   a first piston (36a) arranged within the first cylinder (30a) and a second piston (36b) arranged within the at least one second cylinder (30b).

2. The compressor (20) of claim 1, wherein the fluid provided at the first discharge valve (52a) is configured to bypass the at least one second cylinder (30b).

3. The compressor (20) of claim 1 or 2, wherein the first cylinder (30a) has a first configuration and the at least one second cylinder (30b) has a second configuration, the first configuration and the second configuration being different.

4. The compressor (20) of claim 1, 2 or 3, wherein the at least one second cylinder (30b) is smaller than the first cylinder (30a).

5. The compressor (20) of any preceding claim, wherein an amount of compression that occurs within the at least one second cylinder (30b) is reduced relative to an amount of compression that occurs within the first cylinder (30a); optionall y
   wherein a compression ratio of the first cylinder (30a) to the at least one second cylinder (30b) is between 1:2 and 1:5.

6. The compressor (20) of any preceding claim, wherein the at least one second cylinder (30b) includes a plurality of second cylinders (30b) and the at least one economizer inlet (25) includes a plurality of economizer inlets (25), each of the plurality of second cylinders (30b) is arranged in fluid communication with a different one of the plurality of economizer inlets (25); optionally
   wherein at least one of the plurality of second cylinders (30b) has a different configuration than another of the plurality of second cylinders (30b).

7. A compressor (20) for use in a vapor compression system comprising:

   a housing (22) having a suction inlet (24), an economizer inlet (25), and an outlet (26); and
   a plurality of cylinders arranged within the housing (22) including a first cylinder (30a) configured to receive a first flow of refrigerant from the suction inlet (24) and a second cylinder (30b) configured to receive a second flow of refrigerant from the economizer inlet (25);
   wherein the second flow of refrigerant is compressed within the plurality of cylinders independently from the first flow of refrigerant.

8. The compressor (20) of claim 7, wherein the first cylinder (30a) further includes a first suction valve (50a) arranged in fluid communication with the suction inlet (24) and a first discharge valve (52a) fluidly connected to the outlet (26); and

the second cylinder (30b) further includes a second suction valve (50b) in fluid communication with the economizer inlet (25) and a second discharge valve (52b) fluidly connected to the outlet (26).

9. The compressor (20) of claim 7 or 8, wherein the first cylinder (30a) has a first configuration and the second cylinder (30b) has a second configuration, the first configuration and the second configuration being different.

10. The compressor (20) of claim 7, 8 or 9, wherein the second cylinder (30b) is smaller than the first cylinder (30a).

11. The compressor (20) of any of claims 7 to 10, wherein an amount of compression that occurs within the second cylinder (30b) is reduced relative to an amount of compression that occurs within the first cylinder (30a); optionally
wherein a compression ratio of the first cylinder (30a) to the at least one second cylinder (30b) is between 1:2 and 1:5.

12. A method of operating a compressor (20) comprising:

providing a first flow of refrigerant to a suction inlet (24) of the compressor (20);
compressing the first flow of refrigerant within a first cylinder (30a) of the compressor (20);
providing a second flow of refrigerant to an economizer inlet (25) of the compressor (20);
compressing the second flow of refrigerant within a second cylinder (30b) of the compressor (20); and
delivering the first flow of refrigerant output from the first cylinder (30a) and the second flow of refrigerant output from the second cylinder (30b) to an outlet (26) of the compressor (20).

13. The method of claim 12, wherein only the first flow of refrigerant is compressed within the first cylinder (30a), and only the second flow of refrigerant is compressed within the second cylinder (30b).

14. The method of claim 12 or 13, wherein the first flow of refrigerant output from the first cylinder (30a) and the second flow of refrigerant output from the second cylinder (30b) are delivered to the outlet (26) independently; or
further comprising mixing the first flow of refrigerant output from the first cylinder (30a) and the second flow of refrigerant output from the second cylinder (30b) upstream from the outlet (26).

15. The method of claim 12, 13 or 14, wherein the first cylinder (30a) has a first configuration and the second cylinder (30b) has a second configuration, different from the first configuration; and/or
the method further comprises:

providing a third flow of refrigerant to a second economizer inlet (25) of the compressor (20); and
compressing the third flow of refrigerant within another second cylinder (30b) of the compressor (20).

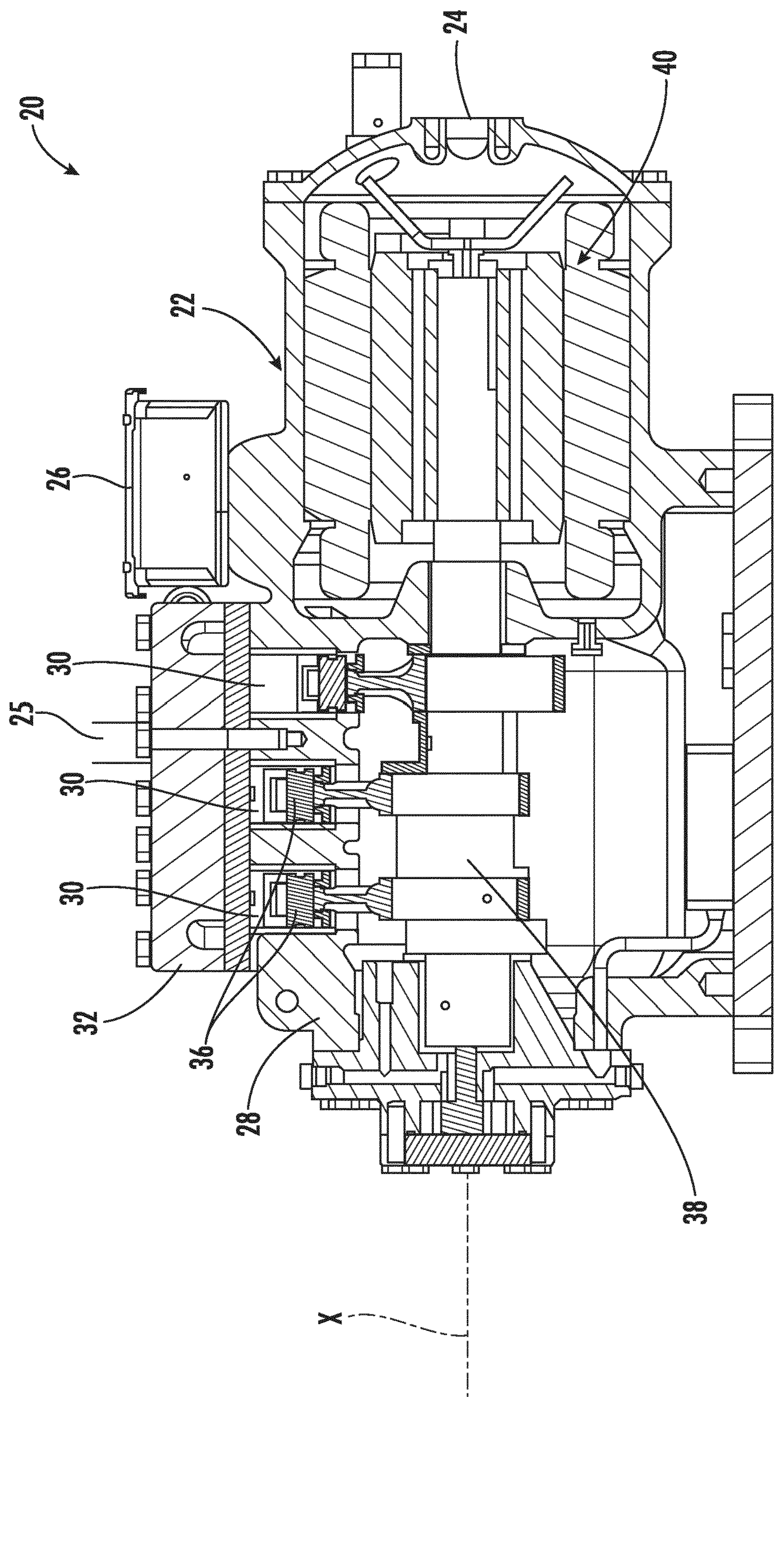

FIG. 1

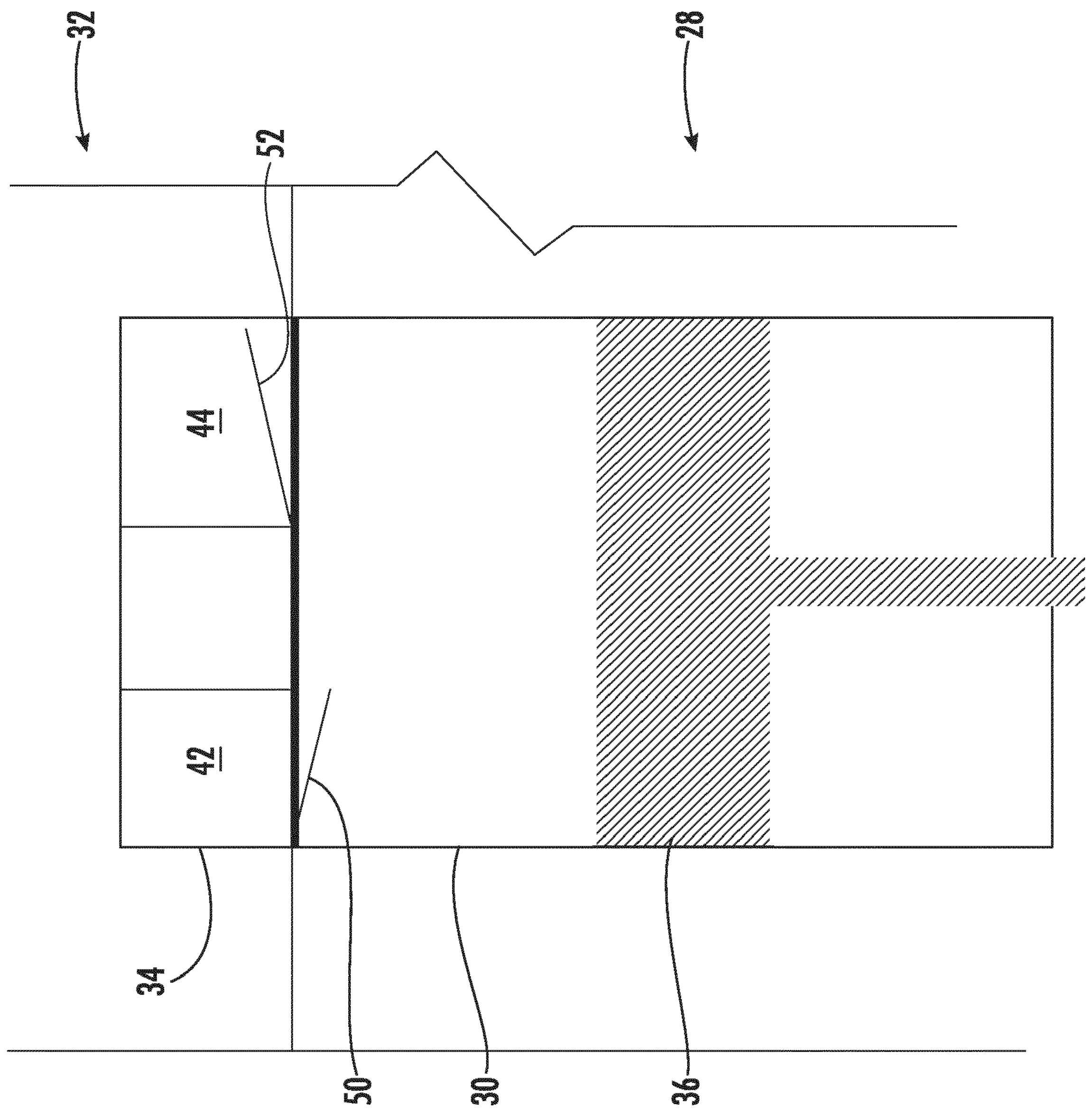

FIG. 2

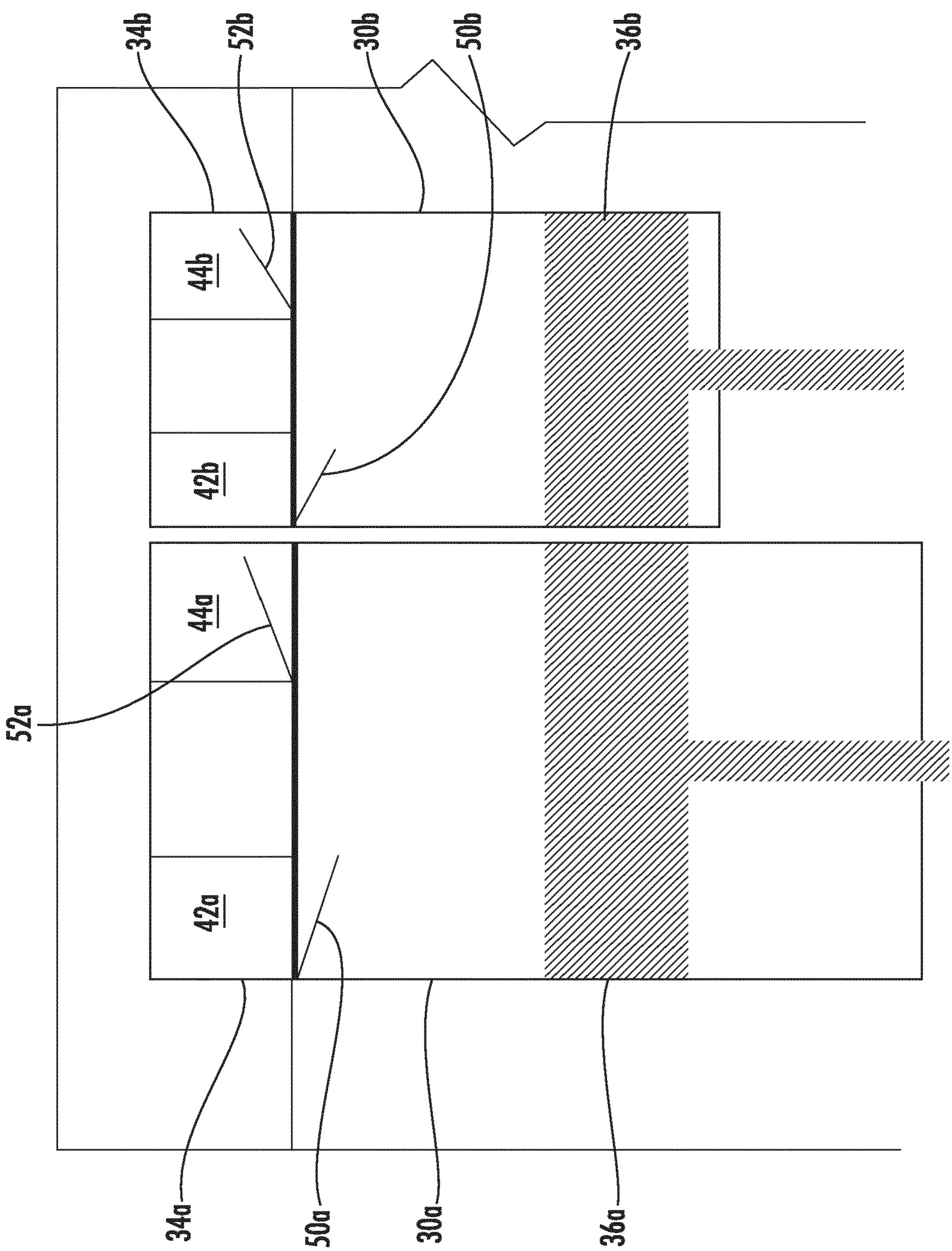

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 8812

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 November 2022	Olona Laglera, C

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CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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