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(54) **OSCILLATION PISTON PUMP**

(76) Inventors: **Christian Beyer**, Koln (DE); **Hermann Boy**, Kerpen (DE); **Rudolf Bahnen**, Roetgen (DE); **Frank Schonborn**, Koln (DE)

Correspondence Address:
Thomas E Kocovsky Jr
Fay Sharpe Fagan Minnich & McKee
1100 Superior Avenue
Seventh Floor
Cleveland, OH 44114-2518 (US)

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(57) **ABSTRACT**

The invention relates to an oscillating piston pump **(1)**, in particular to an oscillating piston vacuum pump. The invention aims to create a range of pumps of this type comprising members which exhibit a different final pressure behaviour and/or a different pumping capacities. To achieve this, the range consists of several identically constructed modules **(2)** of an oscillating piston pump that are connected in parallel and/or in series, according to customer requirements and each module is equipped with an oscillating piston drive.

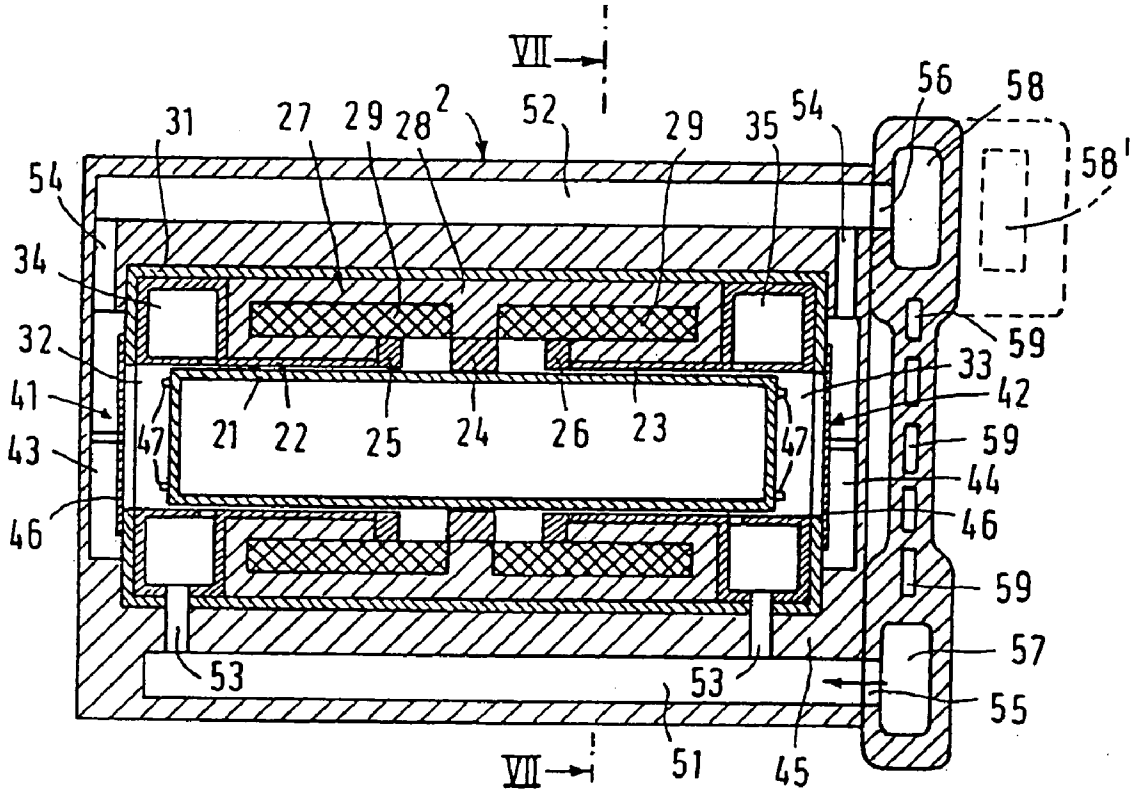


FIG.1

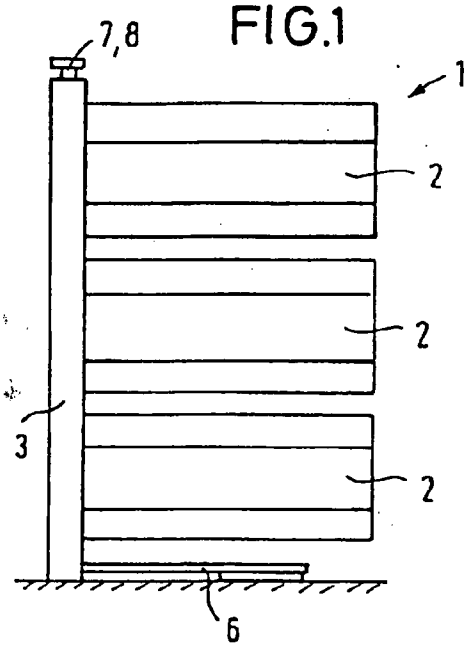


FIG.2

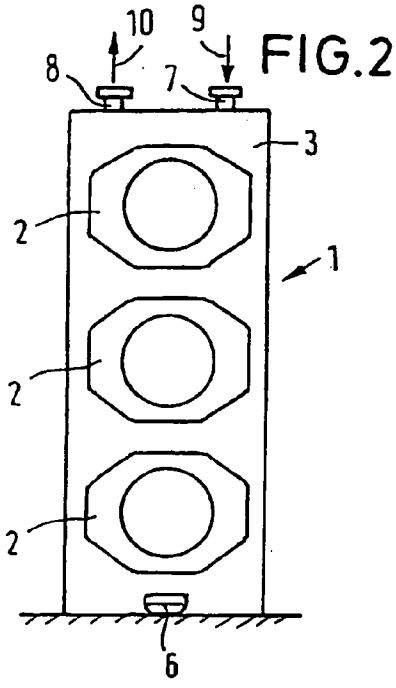


FIG.3

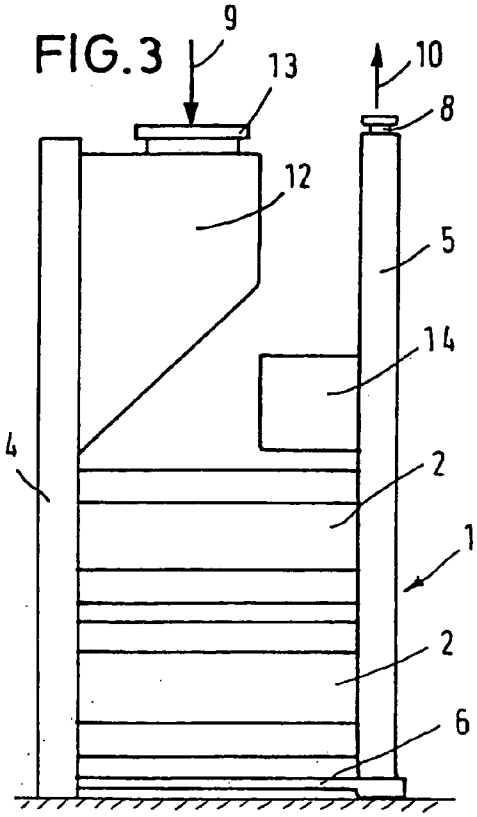


FIG.4

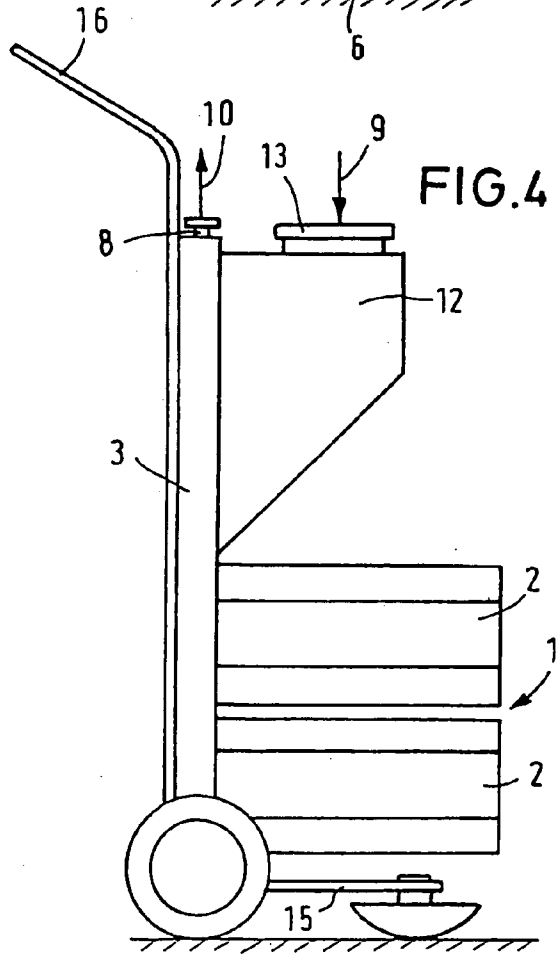


FIG. 5

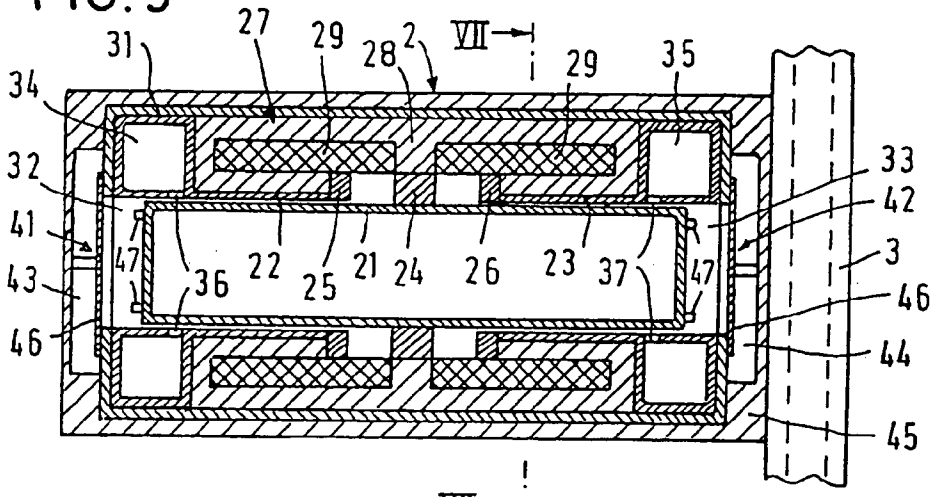


FIG. 6

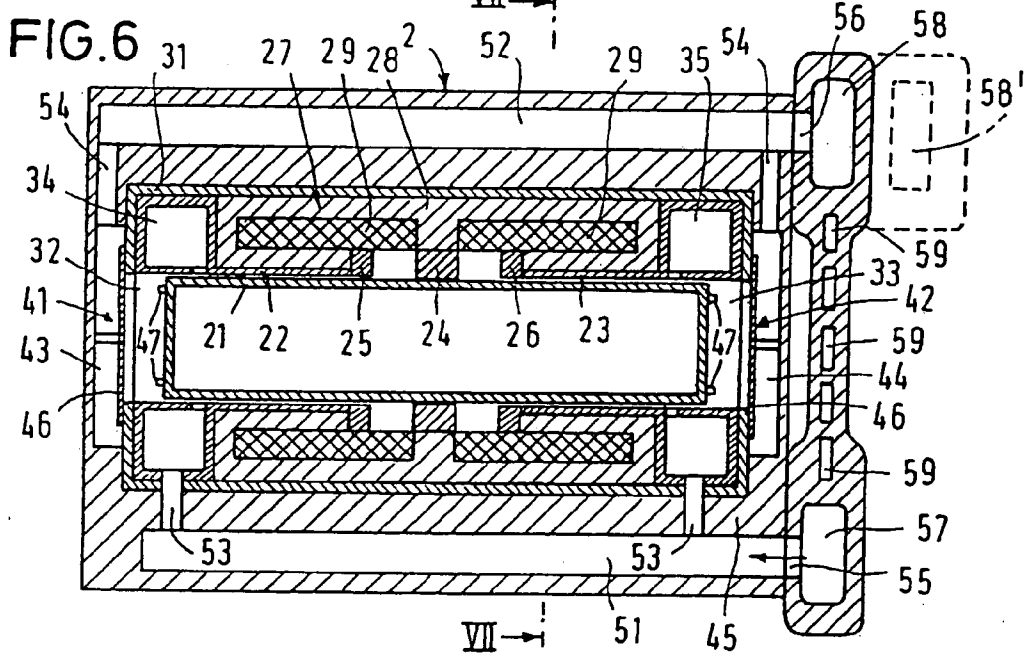


FIG. 7

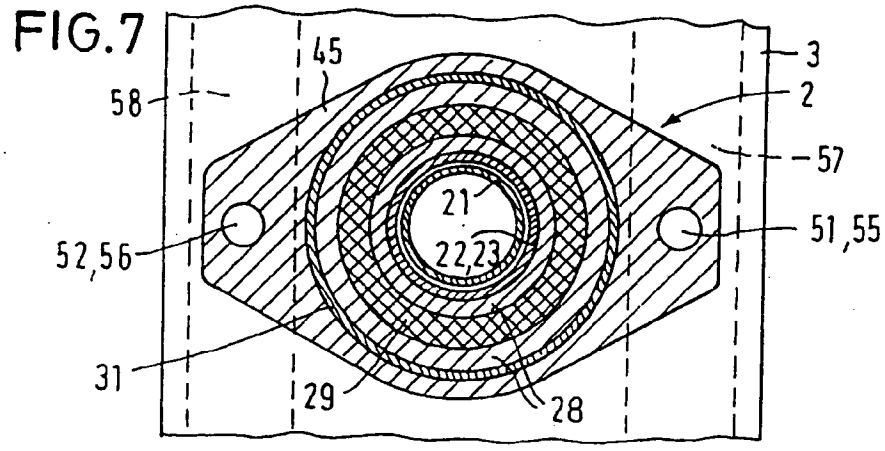


FIG.8a

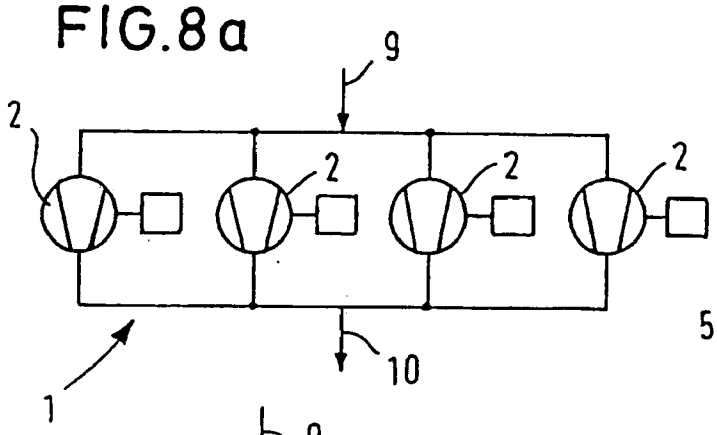


FIG.8b

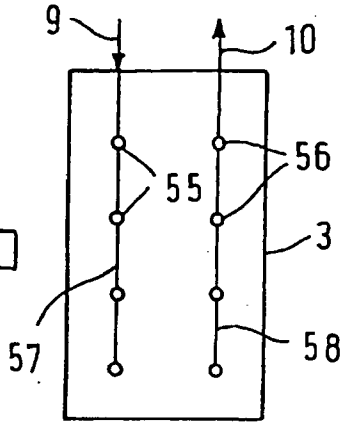


FIG.9a

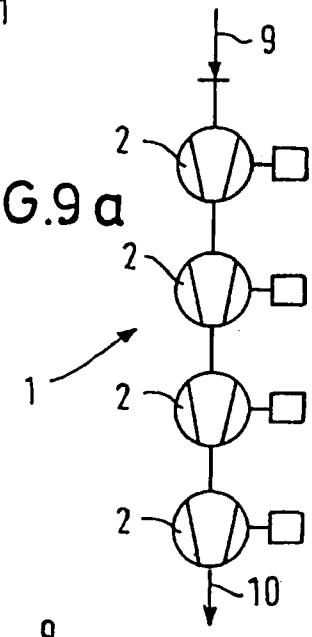
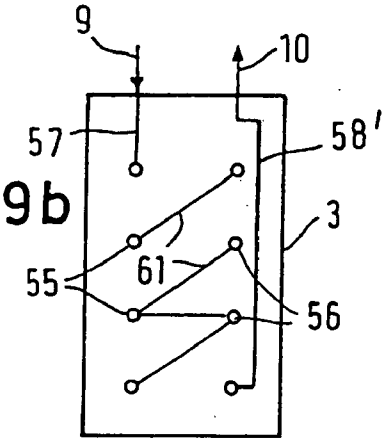


FIG.9b



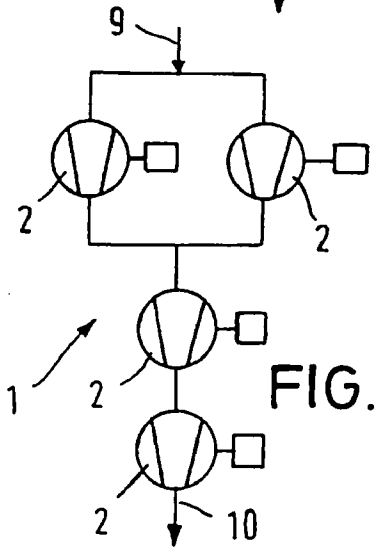
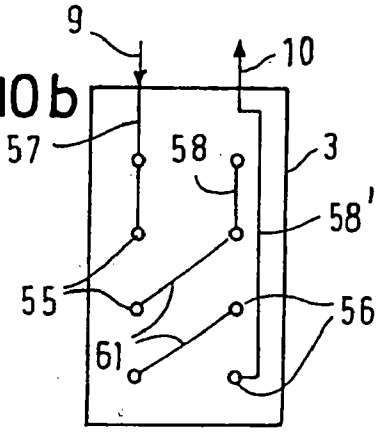


FIG.10a

FIG.10b



OSCILLATION PISTON PUMP

[0001] The present invention relates to an oscillating piston pump, in particular to an oscillating piston vacuum pump, a method for operating a pump of this kind as well as a method for manufacturing a family of pumps of this kind.

[0002] Oscillating piston pumps are known from DE 41 02 710 A1. They exhibit a piston which reciprocates in a cylinder. A linear or reciprocating piston drive serves the purpose of driving the piston, said drive being equipped with electromagnetic means encompassing the piston.

[0003] When employing pumps of this kind as vacuum pumps these may, when suitably selecting the material for the piston and for the cylinder, be operated in a dry manner, i.e. free of lubricant. In piston vacuum pumps in which a crank shaft drive is provided as the means for driving the pistons, this advantage is already being utilised.

[0004] In vacuum pumps it is generally common to manufacture and offer a pump operating according to a certain pumping principle in several sizes—swept volumes, single or multi-stage, so as to be able to meet the customers demand for pumps having differing final pressures and/or pumping capacities. The development and manufacture of such families of pumps is involved.

[0005] It is the task of the present invention to create an oscillating piston pump, in particular an oscillating piston vacuum pump, in which the detailed relatively highly involved development and manufacturing process for arranging a family of pumps covering a broad pumping capacity range and/or final pressure range, is no longer necessary.

[0006] This task is solved through the present invention in that this pump, in particular the vacuum pump, consists of several construction-wise identical modules of an oscillating piston pump which may, depending on customers requirements, be connected in parallel and/or in series and which each exhibit an oscillating piston drive.

[0007] For a pump of this kind it is required to develop and manufacture only a module equipped with piston and linear drive. If oscillating piston pumps of this kind are demanded with final pressures lower than the final pressure attainable by the single module, several such modules may be connected in series. If oscillating piston pumps are demanded with a pumping capacity higher than that of a single module, then several such modules may be connected in parallel. If, for example the single module has a pumping capacity of 1.5 m^3/h then pumps having a pumping capacity of 3, 4.5 or 6 m^3/h can be produced by connecting 2, 3 or 4 pump modules in parallel. Additional benefits are:

[0008] use of the same parts for pumps with different final pressures and for a broad pumping capacity range, whereby through increased production quantities a reduction of costs is attained;

[0009] use in different variants: paralleled modules; series connected modules; in part in parallel, in part series connected modules;

[0010] owing to the multitude of identical parts, the complexity of having to stock individual components is reduced;

[0011] there result simplified spare parts systems, and maintenance is simplified as well;

[0012] the necessity of having to extrapolate the linear drive technology to demanding geometrical regions can be dispensed with.

[0013] In all, with only one module, pump families can be created the members of which have differing final pressure characteristics and/or differing pumping capacities. The module itself is a member of the family. It has the highest final pressure and the lowest pumping capacity.

[0014] Further advantages and details of the present invention shall be explained with reference to the schematically depicted examples of embodiments in drawing FIGS. **1** to **10**. Depicted are in

[0015] drawing FIGS. **1** to **4** views of different embodiments for the pumps according to the present invention,

[0016] drawing **FIGS. 5**[1]) to **7** sectional views through a single module of the pumps according to the present invention,

[1]) Translator's note: The German text states "4" here whereas "5" would be in line with the drawing figures. Therefore the latter has been assumed for the translation.

[0017] drawing FIGS. **8** to **10** schematic representations of possible variants.

[0018] The embodiments of the pump according to the present invention depicted in drawing FIGS. **1** to **4** are designated as **1**, their oscillating piston pump modules as **2**. The modules are affixed to a rail **3** (drawing **FIGS. 1, 2, 4**) or to two rails **4, 5** which on the one hand have a carrying function and which on the other hand are equipped with channels which may be employed as a joint inlet channel, a joint outlet channel, as intermediate channels or also as channels for accepting electrical cables.

[0019] The drawing **FIGS. 1 and 2** depict views of an embodiment with three modules **2**. These are arranged over each other on a rail **3** which is arranged vertically and which is equipped with a foot **6** extending under the modules **2**. Inlet and outlet of the modules **2** each open out on one of their face sides. At this face side the modules are affixed to the rail **3**. The rail **3** is equipped with channels extending in the longitudinal direction. One of these forms the inlet channel to which all inlets of the modules **2** are joined in a sealed manner. A second forms the outlet channel which is joined to all outlets of the modules. On the side of the bottom the inlet channel and the outlet channel are closed. In the area of the upper face side of rail **3** they are equipped with connecting ports **7, 8**. The port **7** assigned to the inlet channel forms the inlet **9**, the port **8** assigned to the outlet channel forms the outlet **10** of the pump **1** according to the present invention.

[0020] The embodiment of the pump **1** in accordance with drawing **FIGS. 1 and 2** is equipped with three modules **2**. Its pumping capacity is equivalent to the sum of the pumping capacities of the identical individual modules. When manufacturing pumps **1** of this kind with a deviating pumping capacity, the number of modules **2** may be varied correspondingly.

[0021] Drawing **FIG. 3** depicts an embodiment in which the modules **2** are affixed to two rails **4, 5**. The rails are supported by a joint foot **6**. In an embodiment of this kind

the first rail **4** may accept the inlet channel and the second rail **5** the outlet channel. For this it is required that the inlet and the outlet of the modules **2** be located on different face sides. Rail **5** contains the outlet channel with the connecting port **8** forming outlet **10**.

[**0022**] In the example of an embodiment in accordance with drawing **FIG. 3** there is located upstream of the two modules **2** a high-vacuum pump **12** (for example, a friction vacuum pump like a turbomolecular, molecular or compound pump). This pump is affixed to rail **4**. Its outlet is joined to the inlet channel in rail **4**. In this instance the inlet channel is closed at both face sides of the rail **4**. The inlet port **13** of the high-vacuum pump **12** forms the inlet **9** of the pump system in accordance with drawing **FIG. 3**.

[**0023**] Drawing **FIG. 3** depicts by way of an example that a joint power supply, control and/or display unit for several or all pumps **2**, **12** may be affixed to one of the rails **4**, **5**. The required cables can be run through channels located in the rails **4**, **5**. A unit **14** of the kind detailed utilised jointly for all pumps may be present also for the pumps **1** in accordance with drawing **FIGS. 1, 2** or **4** having only one rail **3** and said unit may be affixed to this rail **3**. A joint control[2)] unit **14** for the modules **2**, permits especially pumps **1** equipped with an even number of modules **2** to be operated free of vibrations. In accordance with the present invention this is attained in that the pistons of the modules **2** are operated in pairs at identical frequencies and with opposing moving directions.

[2)] Translator's note: The German text states "Stuergerat" here whereas "Steuergerat" would be correct. Therefore the latter has been assumed for the translation.

[**0024**] Drawing **FIG. 4** also depicts an embodiment with two oscillating piston pump modules **2** and a high-vacuum pump **12**. The difference compared to drawing **FIG. 3** is, that only one rail **3** is provided in which the joint inlet channel and the joint outlet channel are located. The inlet channel is closed on both sides. The inlet port of the high-vacuum pump **12** forms the inlet **9** of the pump **1**. The outlet channel opens out into the outlet port **8** on the face side, said outlet port forming the outlet **10** of the pump **1**. Also different compared to drawing **FIG. 3** is, that the rail **3** is supported on a mobile underpart **15** with handle **16**—here a kind of sack trolley. Finally, a unit **14** is not depicted in drawing **FIG. 4**.

[**0025**] Drawing **FIGS. 5, 6** and **7** schematically depict the construction of an example of an embodiment for an oscillating piston pump module **2**. In drawing **FIGS. 5, 6** longitudinal sectional views through a module **2** are depicted perpendicular with respect to each other. These views depict on the one hand a side view of rail **3** (drawing **FIG. 5**) and on the other hand a sectional view (drawing **FIG. 6**). Drawing **FIG. 7** is a sectional view through the module **2** in accordance with drawing **FIGS. 5, 6** at the level of the line VII-VI.

[**0026**] In drawing FIGS. **5** to **7** the centrally arranged piston is designated as **21**. The piston is guided in cylinder sections **22**, **23** axially spaced apart. The piston **21** carries a permanent magnetic ring **24**. This ring **24** is located between permanent magnetic rings **25**, **26** being components of the stator **27**. The sum of the distances between the ring **24** and the ring **25**, **26** corresponds to the amplitude of the piston's motion. A further component of the stator **27** is a yoke component **28** encompassing coils **29** and said yoke component being assigned to the permanent magnetic rings **24**, **25**, **26**.

[**0027**] Together with a first casing **31** encompassing the stator **27**, the module **2** is of a rotationally symmetrical design. In the area of the piston's face sides **21** the casing **31** forms the compression chambers **32** and **33**. Located to the side next to the compression chambers **32**, **33** is each a gas inlet chamber **34** and **35** respectively. Via inlet gaps **36** and **37** respectively in the cylindrical sections **22**, **23** said gas inlet chambers open out into the respective compression chamber **32** and **33**. The motion of the piston effects opening and closing of the inlet gaps **36**, **37**. Assigned to the compression chambers **32**, **33** are on the face side each an outlet valve **41** and **42** respectively these also being actuated by[3)] piston **21**. These are located in outlet chambers **43**, **44** being formed in a second outer casing **45** accepting the first casing **31**. Outlet valves of this kind are known only from DE 196 34 517 A1. A flexible or flexibly suspended valve disk **46** is actuated by piston **21**. In the presented example of an embodiment, the face sides of the piston **21** are equipped at the side with naps **47** which lift the outer rims of the flexibly designed valve disk **46** located centrally in the outlet chambers **43**, **44**.

[3)] Translator's note: The German text states "zum Kolben" here whereas "vom Kolben" would be correct. Therefore the latter has been assumed for the translation.

[**0028**] In particular from drawing **FIG. 7** it is apparent that the outer casing **45** has a cross-section of approximately oval design. It encompasses the rotationally symmetrically designed linear drive in casing **31**. In opposing areas having a thicker casing wall there is located on one side an inlet bore **51** and on the other side an outlet bore **52**. These extend in parallel to the piston **21**. The inlet bore **51** is linked via lateral bores **53** to the gas inlet chambers **34**, **35**. The outlet chambers **43**, **44** are linked via lateral bores **54** to the outlet bore **52**.

[**0029**] In the embodiment depicted, both bores **51**, **52** open out at one of the face sides of the module **2** (c.f. in particular drawing **FIG. 6**) and form the inlet **55** and outlet **56** respectively of the module **2**. Assigned to this face side is the rail **3**. Located in the rail **3** is the inlet channel **57** which is linked to the inlet **55** of the modules **2** in a sealed manner. At the level of the outlets **56** of the modules **2** there is located the outlet channel **58** of the rail **3** which are also—through means not explicitly depicted, mechanical means or adhesive—joined in a sealed manner. Inlet channel **57** and outlet channel **58** are outlined in drawing **FIG. 7** by dashed lines.

[**0030**] Further channels **59** in the rail **3** are depicted in drawing **FIG. 6**. These serve the purpose of accepting electric cables employed for supplying power to the linear drives, for example. Also linking of the modules **2** as well as—if present—the high-vacuum pump **12** to a joint power supply, display and control unit (drawing **FIG. 3**) may be effected through the further channels.

[**0031**] Drawing FIGS. **8** to **10** depict further possible variants with respect to connecting the modules **2**.

[**0032**] In the solution in accordance with drawing **8***a, b* all modules **2** are connected in parallel. This then expediently also applies to the stages present in a module **2** if it is of a two-stage design (drawing **FIGS. 5, 6**). At the face sides, the

inlets **55** of the modules **2** open out into a joint inlet channel **57** in rail **3** (drawing **FIG. 8***b*). The outlets **56** open into the joint outlet channel **58**.

[**0033**] In the embodiment in accordance with drawing **FIGS. 9***a*, **9***b* all modules **2** are connected in series, for example also the stages contained in module **2**, as detailed in DE 199 17 560.8. The inlet channel **57** in rail **3** (drawing **FIG. 9***b*) extends only up to the inlet **55** of the first module **2**. Intermediate channels **61** connect each the outlet **56** of a module **2** to the inlet **55** of the next module **2**. The outlet **56** of the last module **2** is linked to an outlet channel **58'**, which may, for example, be provided separately (c.f. also drawing **FIG. 5**, dashed addition) in rail **3**.

[**0034**] Drawing **FIGS. 10***a*, b depict a solution in which the first two modules **2** are connected in parallel and the two further modules **2** are connected in series (drawing **FIG. 10***a*). The corresponding arrangement of the channels **57**, **58**, **58'**, **61** in rail **3** is depicted in drawing **FIG. 10***b*.

[**0035**] The so far described modules **2** of the pump **1** according to the present invention have compression chambers **32**, **33** at both face sides of the piston **21**. Within the scope of the present invention also modules equipped with only one or more than two compression chambers respectively may be employed. The latter are basically known from EP 607 687 A2. The therein detailed piston pumps are, however, equipped with a crankshaft drive.

1. Oscillating piston pump **(1)**, in particular an oscillating piston vacuum pump, wherein it consists of several modules **(2)** of the same design of an oscillation piston pump which are, depending on customer requirements, connected in parallel and/or in series, each module being equipped with a drive for the oscillating piston.

2. Pump according to claim 1, wherein the oscillating piston pump modules **(2)** are affixed jointly on to a rail **(3)**.

3. Pump according to claim 2, wherein the inlet and the outlet **(55, 56)** of the oscillating piston pump modules **(2)** are located in the area of one of the two face sides, where the modules **(2)** are affixed at this face side to the rail **(3)**, where in the instance of modules **(2)** connected in parallel there is located in the rail each a joint inlet channel **(57)** and a joint outlet channel **(58)** and where one opening of the inlet channel forms the inlet **(9)** of the pump **(1)** and one opening of the outlet channel forms the outlet **(10)** of the pump **(2)**.

4. Pump according to claim 2, wherein in the rail **(3)** there are provided intermediate channels **(61)** which in the instance of series connected modules **(2)** join the outlet **(56)** of one module **(2)** to the inlet **(55)** of the next module **(2)**.

5. Pump according to claim 2, wherein one of the face sides of the oscillating piston pump modules **(2)** is each equipped with the inlet **(55)** and the further face sides are each equipped with the outlet **(56)** and where two rails **(4, 5)** are present of which one is equipped with the joint inlet channel **(57)** and the other with a joint outlet channel **(58)**.

6. Pump according to claim 2, **3**, **4** or **5**, wherein the rail(s) **(3, 4, 5)** has/have carrying functions.

7. Pump according to one of the claims 2 to 6, wherein the rail(s) **(3, 4, 5)** is/are a component of a frame, a cart **(15, 16)** or alike.

8. Pump according to one of the claims 2 to 7, wherein the rail(s) **(3, 4, 5)** is/are equipped with further channels **(59)** serving the purpose of accommodating electrical cables.

9. Pump according to one of the claims 2 to 8, wherein the rail(s) **(3, 4, 5)** is/are formed by an extruded profile component.

10. Pump according to one of the claims 1 to 9, wherein there are located in the module **(2)** two or more pumping stages and where these may be connected, depending on customer requirements, parallel or in series.

11. Pump according to one of the above claims, wherein there is located upstream of the oscillating piston pump **(1)** a high-vacuum pump **(12)** and where the inlet of the high-vacuum pump **(12)** forms the inlet **(9)** of the pumping system.

12. Pump according to claim 10 and one of the claims 2 to 8, wherein the high-vacuum pump **(12)** is also affixed to the rail **(3)** or at one of the rails **(4, 5)** respectively.

13. Pump according to one of the above claims, wherein all modules **(2)** of the oscillating piston vacuum pump **(1)** and the possibly present high-vacuum pump **(12)** are equipped with a joint power supply, display and/or control unit **(14)**.

14. Pump according to one of the above claims, wherein the modules **(2)** are equipped with an outer casing **(45)** in which there are located bores **(51, 52)** extending in parallel to the piston **(21)** of which one forms the inlet bore and the other the outlet bore.

15. Pump according to claim 12, wherein the outer casing **(45)** is designed to be oval in shape and where each one of the bores **(51, 52)** is located in the area of the thicker wall sections.

16. Method for operating a pump **(1)** according to one of the claims 1 to 13, wherein, the linear drives of the individual modules **(2)** can be so driven that the oscillating pistons **(21)** of the pump modules **(2)** perform in pairs an opposing motion with respect to each other.

17. Method for manufacturing oscillating piston pumps **(1)**, in particular oscillating piston vacuum pumps with different pumping capacities, wherein several oscillating piston pump modules **(2)** of the same design are connected in parallel and/or in series and where the number of modules connected in parallel and/or in series is so selected that the sum of their pumping capacities corresponds to the desired pumping capacity or so that the final pressure corresponds to the desired final pressure.

18. Method according to claim 17, wherein they are mounted next or above each other to a joint **(3)** or to two rails **(4, 5)** and where the inlet openings **(55)** of the modules **(2)** are joined in a sealed manner to a joint inlet channel **(57)** and the outlet openings **(56)** of the modules **(2)** to a joint outlet channel **(58)**.

* * * * *