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(54) **HYDRAULIC PUMP UNIT AND METHOD OF ASSEMBLING A HYDRAULIC PUMP UNIT**

(57) Hydraulic pump unit 1 with a radial piston pump 2 and multiple line connectors 99 for connecting a set of hydraulic actuators 110 to the pump unit via actuator lines. The pump unit comprises a main body 5 including a channel system 50 with multiple ducts 501 form a flow paths of a hydraulic circuit. The duct ends 502 define multiple ports in a common port face 51. The main body 5 define a generic part of the hydraulic circuit. The pump unit further comprises a throttle plate 7 with at least one throttle orifice 70 which is sized to provide a predetermined throttling of hydraulic liquid. The throttle plate is specific for a particular predetermined hydraulic circuit. Advantageously, the throttle plate 7 is replaceable by another throttle plate to obtain a different throttling property in a hydraulic circuit embedded in the pump unit.

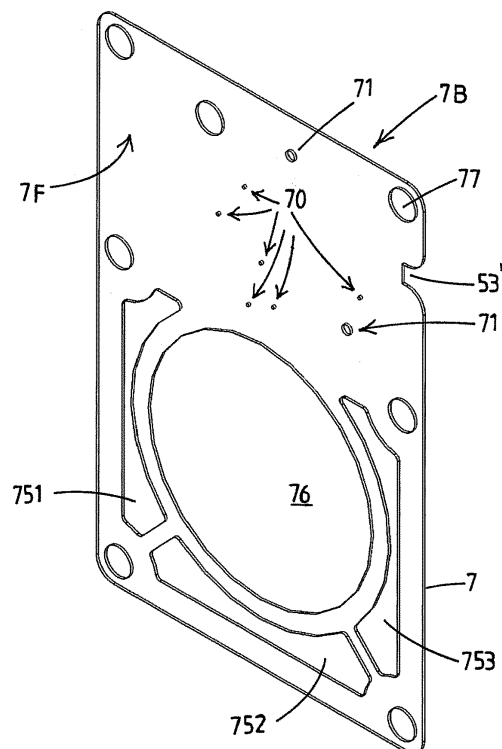


Fig.17

Description

[0001] The present invention relates to a hydraulic pump unit. The hydraulic pump unit is configured to supply pressurised hydraulic liquid to a set of hydraulic actuators. In particular, the set of hydraulic actuators may comprise a plurality of actuators wherein a first actuator is to be moved independently from a second actuator.

[0002] The hydraulic pump unit comprises a pump, a reservoir for a hydraulic liquid, and multiple line connectors for connecting the set of hydraulic actuators to the pump unit via actuator lines, e.g. via flexible hydraulic hoses. The pump unit has at least one valve seat allowing to install an electrically operable valve or such a valve being installed, e.g. a directional valve, to control the flow of hydraulic liquid. Further the hydraulic pump unit comprises a main body including a channel system for the hydraulic liquid. The channel system comprises multiple ducts which interconnect the pump, the reservoir, and the at least one valve seat. Each duct forms a flow path of a hydraulic circuit. The channel system includes ducts which have duct ends which are situated in a surface of the main body. The duct ends define multiple ports in a common port face.

[0003] The invention also relates to a method of assembling a hydraulic pump unit to obtain a hydraulic pump unit including a predetermined configuration of a hydraulic circuit which pump unit is dedicated to control a set of hydraulic actuators, in particular a set of motion independent hydraulic actuators.

[0004] A hydraulic pump unit is known from WO2010/127744. This known hydraulic unit assembled from several components including a pump, a motor and a tank. The hydraulic unit comprises a housing and a core. The core is received in a bore in the housing. A part of the outer surface of the core contacts the bore in the housing. Groove-shaped surface flow channels are provided in the area of the adjoining surface of the core and/or of the housing. The pump and the motor are mounted at one axial end of the core. The tank is mounted at the opposite axial end of the core.

[0005] The pump unit of the invention, like the pump unit of WO2010/127744, may be embodied as a small hydraulic power pack, preferably with integrated pump motor, e.g. for use in the automotive industry, e.g. for hydraulic actuation of one or more movable car elements like a convertible roof, e.g. including a tonneau cover, one or more doors of a car, a hood, etc.

[0006] DE10.2007.052.504 discloses an electro-hydraulic driving system for operating a convertible roof of a vehicle. The driving system has a centrally positioned aggregate for energising several actuators. The driving system comprises a motor and an electronic unit which are mounted to a block shaped pump housing including two pumps. An adapter block is mounted to the pump housing, in which a gasket is clamped in between the adapter block and the pump housing to prevent any liquid leakages. The adapter block is configured to connect a

plurality of actuators. The adapter block includes an internal channel system which allows a direct connection of the actuators without any branching of actuator lines.

[0007] The channel system of the adapter block is manufactured by drilling a plurality of crossing boreholes. Longitudinal boreholes are drilled in a length direction in which transversal boreholes are drilled in a transversal direction to intersect the longitudinal boreholes.

[0008] Producing such a channel system has several drawbacks. Producing such a channel system is labour-intensive and vulnerable for failures which lead to rejected products. The drilling of the transversal boreholes is labour intensive, because after drilling the boreholes, these boreholes need to be closed again by placing a plug like a Koenig expander. To enable a placement of a plug, the borehole must have a locally enlarged diameter which increases an effort in production. Failures occur when the transversal boreholes are erroneous positioned or not accurately directed. Further, failures are caused by contaminated boreholes. Drilled boreholes might include tiny metal chips which might cause operational failures.

[0009] Applications like the automotive industry require that the hydraulic pump units are manufactured and assembled in a mass production environment at low cost. To obtain a cost effective mass production, high requirements have to be met regarding a logistics for manufacturing and storage of components and regarding the assembly effort and time for assembling components to manufacture the pump units. For example when supplied to the automotive industry, where many different cars, e.g. having different convertible roof systems, are manufactured to specific orders from clients, the pump units have to be delivered to the car assembly line according to the just-in-time (JIT) principle. This JIT principle requires an optimised manufacturing and logistic operation at the side of the hydraulic pump unit manufacturer in order to reduce e.g. storage costs for ready to deliver pump units.

[0010] A first desire is to provide a hydraulic pump unit having a design that allows to vary the effective hydraulic circuit in a structurally simple manner, e.g. allowing for limited effort and/or time needed for the assembly of the pump unit.

[0011] A further desire is to provide a useable alternative to existing hydraulic pump units.

[0012] According to a first aspect of the invention, the invention relates to a the hydraulic pump unit comprising a pump, in particular a rotary drive shaft operated pump, a reservoir for hydraulic liquid, multiple line connectors for connecting the set of hydraulic actuators to the pump unit via actuator lines, and at least one valve seat, wherein an electrically operable valve is or can be installed at the at least one valve seat. Further, the hydraulic pump unit comprises a main body including a channel system for the hydraulic liquid. The channel system comprises multiple ducts which interconnect the pump, the reservoir and the at least one valve seat. Each duct forms a flow

path of a hydraulic circuit. The channel system includes ducts which have duct ends which are situated in a surface of the main body. The duct ends define multiple ports in a common port face.

[0013] According to the first aspect of the invention, the pump unit further comprises a throttle plate. The throttle plate comprises at least one throttle orifice. The throttle orifice extends from a back side to a front side of the throttle plate. The throttle orifice is sized to provide a predetermined throttling of hydraulic liquid. In particular, the throttle orifice is positioned at the throttle plate in alignment with a port of the port face of the main body. The throttle plate is retained in position in parallel with the port face. The throttle plate is specific for a particular predetermined hydraulic circuit.

[0014] Advantageously, the throttle plate is replaceable by another throttle plate to obtain a different throttling property in a hydraulic circuit embedded in the pump unit.

[0015] In an embodiment of the pump unit according to the invention, the port face is a planar face of an outer surface of the main body which allows a reduction of an assembly time in a mass production of the pump unit.

[0016] In an embodiment of the pump unit according to the invention, a single throttle orifice comprises a group of filter apertures that throttle and also filter a passing hydraulic liquid. Advantageously, the filter apertures provide a double function which allows a reduction of components of the pump unit which contributes to a cost-effective mass production of the pump unit.

[0017] According to a second aspect of the invention a hydraulic pump unit according to clause 1 is proposed.

[0018] The hydraulic pump unit according to the invention provides an advantage in that the configuration of the hydraulic pump unit is easy adaptable in the manufacturing process, e.g. to meet a specific demand, e.g. from a car manufacturer, by selecting from a set of different function plates the one function plate that provides for the desired hydraulic circuit for controlling the hydraulic actuators. The function plate is relatively easy to manufacture and easy to handle, and the sandwiching of the function plate between the main body and the end body allows to achieve the desired pressure resistant sealing without great effort, even at the pressure of the hydraulic liquid which may for example exceed 50 bars, or even 100 bars.

[0019] Compared to the WO2010/127744 the plate shape of the function plate, the planar embodiment of the port face, and the sandwiching by means of the end body, avoid problems with tolerances, unroundness, sealing, etc. that may be expected when mating the core with the cylindrical bore.

[0020] Compared to the hydraulic system of DE10.2007.052.504, a function plate according to the invention which is sandwiched in between the end body and the main body allows a reduction of a complexity of a present channel system or even allows to completely omit such a channel system. A channel system can may have a standardised configuration to provide a generic

part of a hydraulic circuit, while the addition of the function plate to the pump unit makes the pump unit specific for a particular application. If a channel system is provided in an end body, such channel system might just relate to a generic part of a hydraulic circuit including just basic functions which are general for multiple applications, while the additional function plate relates to a specific part of a typical application. Herewith, a number of necessarily different configurations of channel systems can be strongly reduced which may strongly reduce an amount of failures and product rejections during production.

[0021] The 2D plate shape of the function plate including a slotted passageway to obtain a predetermined hydraulic circuit allows a production by laser cutting technology which is advantageous over a 3D drilling technology which is used in producing a channel system out of boreholes. Herewith, the pump unit according to the invention can be manufactured more effectively in a plurality of configurations.

[0022] In a practical embodiment the end body is secured to the main body via one or more threaded fasteners, e.g. bolts, that are tightened to achieve the desired sealing between any interface of the one or more plates, the end body, and main body, that is transgressed by hydraulic liquid. Other fasteners or fastening techniques, e.g. leading to a permanent securing of the end body, one or more plates, and main body, may also be envisaged. For example the end body and main body are glued or welded to one another.

[0023] The function plate is preferably directly mounted against the planar port face situated at an outer surface of the main body.

[0024] It is envisaged that the end body and function plate, and any other plate if present, may be releasable mounted in the pump unit, e.g. allowing to exchange one or more plates in a ready made pump unit, e.g. for maintenance. It is however also envisaged that these components are permanently secured to one another in some way. For example a permanent stack can be made of one or more function plates, possibly in combination with one or more of a throttle plate and/or connector plate as described herein, which are permanently secured to another.

[0025] The planar shape and positioning of the port face at an outer surface contributes to a simple assembly and may allow for a reduction of an assembly time. The planar port face facilitates an alignment of the slotted passageway of the function plate to corresponding ports of the port face.

[0026] The end body allows to press the function plate onto the planar port face and thereby provides a strong and reliable mounting which avoids liquid leakages.

[0027] Additionally, the presence of the port face at an outer surface of the main body may contribute to a reduction of an assembly time in that components of the pump unit which include universal features can remain pre-assembled when mounting a specific function plate

to obtain a specific hydraulic circuit.

[0028] The hydraulic circuit which is embedded in the hydraulic pump unit is defined by a plurality of flow paths. The flow paths are substantially determined by the channel system of the main body in combination with at least the function plate, possibly one or more of the other plates as described herein.

[0029] A layout of the at least one slotted hydraulic liquid passageway of the function plate determines a particular liquid connection in between ports in the port face of the main body. The layout of each passageway determines a particular flow path of the hydraulic circuit. Hence, the function plate can be prepared in accordance with a predetermined hydraulic circuit by designing the at least one slotted passageway in a desired configuration.

[0030] A first function plate may define a first hydraulic circuit of the hydraulic pump unit. A second function plate may define a second hydraulic circuit of the hydraulic pump unit. By selecting during the manufacturing process of the pump unit either the first or the second function plate, the hydraulic circuit of the hydraulic pump unit may be adapted into a first hydraulic circuit or a different, second hydraulic circuit.

[0031] Advantageously, the invention allows to manufacture a main body that is combinable with a selected one of multiple different function plates to meet, e.g. in a Just-in-Time situation, a stream of frequently varying orders from clients, e.g. as in the automotive industry.

[0032] Herewith, a hydraulic pump unit according to the invention can be dedicated in a simple manner to a particular hydraulic actuating device by mounting the hydraulic pump unit with a dedicated function plate.

[0033] Hereafter, further embodiments of the hydraulic pump unit according to the invention will be described with reference to a spatial relation of the components of the pump unit. The pump unit is described in a spatial orientation in which the main body is positioned at a back side and in which the end body is positioned at a front side of the pump unit. In a frontal view of the pump unit, the main body is positioned behind the end body. A reference to an axial direction means a reference to a linear direction which extends from the back side to the front side of the pump unit.

[0034] In an embodiment of the hydraulic pump unit, the pump unit comprises multiple line connectors for connecting actuator lines to the pump unit, which line connectors are provided on the main body. The line connectors are preferably incorporated in the main body to provide a one piece item, but may also be situated at a separate body which is mountable to the main body, e.g. by bolts. The positioning of the line connectors on the main body provides an advantage in that the configuration of the end body may remain simple. The main body which includes the channel system may be manufactured by drilling and milling operations, in which substantially all complex features of the hydraulic circuit are incorporated in the main body. Advantageously, the complexity of the

pump unit manufacturing can be concentrated at one part of the pump unit, i.e. the main body, while leaving the remaining parts of the pump unit simple for manufacturing. Herewith, the hydraulic pump unit can be manufactured cost effective in a mass production.

[0035] In a further embodiment of the hydraulic pump unit, the end body is arranged without a line connector which simplifies the configuration. The end body may - similar to the main body - include an end body port face and an end body channel system which is configured to provide a flow path in between the first and second port of the end body port face. The ports of the end body port face are preferably aligned with the ports of the main body port face. Herewith, the end body channel system may be configured to return a flow of liquid originating from a first port of the end body to a second port of the end body. By providing a specific configuration of the end body channel system, a predetermined flow path may be obtained which is characteristic for a particular hydraulic circuit. Advantageously, the end body which has a simple configuration which allows a cost-effective manufacturing can be interchanged to obtain of a particular hydraulic circuit.

[0036] In an embodiment according to the invention in which the end body is arranged without a line connector and without a channel system. The end body may have a simple configuration. The end body may be a clamping body, in particular a clamping plate, in which the end body is plate shaped including a plurality of mounting holes for introducing bolts to clamp and mount the function plate to the main body.

[0037] In an embodiment of the hydraulic pump unit according to the invention, the main body and the end body each comprise at least one multiple line connector for connecting actuator lines to the pump unit.

[0038] In an embodiment of the hydraulic pump unit according to the invention, the multiple line connectors are provided on the end body. Preferably, the end body comprises at least two pairs of line connectors for connecting the pump unit to the set of motion independent actuators. Each pair of line connectors may connect two lines, e.g. leading to one or more double-acting hydraulic actuators, e.g. linear hydraulic cylinders.

[0039] Preferably, all line connectors of the hydraulic pump unit are provided on the end body. The end body comprises an end body channel system for conducting a liquid. The end body channel system comprises multiple ducts, in which each duct forms a flow path of a hydraulic circuit. The end body channel system includes ducts having duct ends which are situated in a planar face of an outer surface of the end body. The duct ends define multiple ports in an end body port face. The end body channel system interconnects a line connector and a port of the end body port face.

[0040] Preferably, the line connectors are positioned at a front side of the end body, and the multiple ports are positioned at a back side of the end body. Particularly, the ports of the end body port face are aligned with the

ports situated in the port face of the main body. In particular, the end body port face is in mirror symmetry with the port face of the main body.

[0041] In an embodiment of the hydraulic pump unit the end body comprises a motor mount for mounting a motor in operable connection with the pump. Preferably, the motor mount is positioned at a side of the end body opposite the end body port face. Herewith, the end body is assembled in between the motor and the function plate of the pump unit. Advantageously, the motor mount at the end body provides a simple layout of the pump unit which contributes to an ease of assembly.

[0042] In an embodiment of the hydraulic pump unit, the function plate comprises multiple hydraulic liquid holes which each extend from a back side to a front side through the function plate. The multiple holes are preferably each arranged in alignment with one of the multiple ports of the port face of the main body. The multiple holes each provide a flow path, in particular a through flow, from the main body through the function plate towards the end body. The multiple holes may provide a connection of ports of the port face of the main body to one or more ports of the end body port face, such that a particular hydraulic circuit is obtained. In particular, the holes of the function plate may interconnect line connectors at the end body with the channel system of the main body, such that the line connectors are connected with the pump, the reservoir, and the at least one valve. Advantageously, the multiple holes in combination with the at least one slotted passageway contributes to the freedom to design different hydraulic circuits.

[0043] In an embodiment of the hydraulic pump unit, the function plate comprises at least one seal rib. The at least one seal rib extends across the function plate along an outer contour of the slotted passageway, encircling said passageway in order to avoid leakage of hydraulic liquid. Advantageously, the at least one seal rib seals the slotted passageway to prevent leakages of liquid across the function plate. Preferably, the at least one seal rib is fixedly secured, e.g. vulcanised, to the function plate. Preferably, the at least one seal rib comprises a silicone or rubber material. A permanent integration of the seal rib with the function plate allows for a reduction of assembly effort and/or time in a mass production of the pump unit.

[0044] In an embodiment of the hydraulic pump unit, the function plate comprises multiple slotted passageways and multiple seal ribs, in which each individual slotted passageway is provided with, e.g. encircled by, a respective individual seal rib. Advantageously, the arrangement of individual separate seal ribs prevent a leakage of liquid in between separate passageways.

[0045] In an embodiment of the hydraulic pump unit, each slotted hydraulic liquid passageway or hydraulic liquid hole of a plate is encircled by a respective seal rib, e.g. seal ribs being present at two sides of the plate in case of a hydraulic liquid hole through the plate.

[0046] For a slotted passageway it is envisaged that

such passageway may include a section that is only present as a groove at one side of the plate, or be formed entirely as a groove at one side of a plate.

[0047] It is envisaged that a slotted passageway may connect to one or more through holes that extend through the plate, with the slotted passageway being a groove formed in one side of the plate.

[0048] In an embodiment a slotted passageway at a back side of the function plate is provided with a seal rib and a slotted passageway at a front side of the function plate is provided with a seal rib.

[0049] Advantageously, the function plate and/or the connector plate, which will be described later, is provided with permanently integrated sealing members, e.g. the mentioned sealing ribs, and can be retained in the sandwich without the use of an additional, separate sealing member contact one or both sides of the plate, e.g. like a separate seal gasket plate.

[0050] In an embodiment of the hydraulic pump unit, the function plate and/or the connector plate, which will be described later, is a laminated plate. The laminated plate comprises at least a front layer and a back layer. Lamination means that the layers of the laminated plate are stacked and fixed, preferably permanently, together about substantially the entire contact surface to obtain a one piece item. The front layer may comprise one or more slotted passageways. The back layer may comprise one or more slotted passageways. Any through holes extend through both the front and the back layer.

[0051] The front and/or back layer can be made of plastic material, e.g. injection moulded, e.g. in a 2K-process wherein the one or more seal ribs are directly integrated with the front layer and/or back layer. As will be explained the laminated plate may include one or more intermediate layers, e.g. a filter material layer. For example the front and/or back layer are of plastic and moulded onto the filter material layer.

[0052] Preferably, the front layer includes a different configuration of the at least one slotted passageway in comparison with the at least one slotted passageway of the back layer to obtain a specific configuration of the plate which is dedicated to a particular hydraulic circuit.

[0053] In an embodiment, the function plate is a laminated plate. The laminated plate comprises at least two layers including a support layer for providing rigidity to the function plate. The support layer comprises preferably a metal plate. The laminated plate further comprises at least one seal layer for a liquid tight sealing of the function plate under a compression. The seal layer includes a compressible sealing material, which is preferably an elastomer. In an embodiment, the seal layer may comprise a vulcanisable material like rubber.

[0054] In an embodiment, the seal layer is adapted in correspondence with a pattern of the at least one slotted passageway and/or at least one hole. Herewith, a predefined volume of sealing material circumvents a slotted passageway or hole of the function plate. The predefined volume has a width of at least 2mm and at most 10mm.

Advantageously, an applied compression in an assembly of the function plate to the main body results in a liquid tight connection.

[0055] In an embodiment, the at least one slotted passageway of the function and/or connector plate is spaced at a distance of at least 2mm away from another slotted passageway or borehole. Advantageously, such a spacing provides sufficient resistance to prevent any leakage in between a passageway and hole of a pattern.

[0056] In an embodiment, a stack of at least one function plate is sandwiched between the port face of the main body and the port face of the end body. The stack of plates is a multi-layer one piece item provided by producing a fixed connection of several plates, e.g. by fixating a stack of prefabricated plates in which each plate is made by a cutting technology.

[0057] In an embodiment, the laminated plate, e.g. function plate, further comprises an intermediate layer. The intermediate layer is positioned in between the front and back layer. Preferably, the intermediate layer comprises a filter material element, in particular a filter material layer, e.g. a fine woven membrane. Preferably, the filter element or layer comprises a woven filter material. The intermediate layer may comprise a support sub-layer for supporting the filter membrane. Advantageously, the filter membrane of the intermediate layer may provide a filter function for the hydraulic liquid that passes through a hydraulic liquid hole that is spanned by said filter layer, e.g. the filter layer serving to extract air from the hydraulic liquid which may have become entrapped in the liquid due to foaming as high velocity liquid arrives in the reservoir.

[0058] In a further embodiment of the hydraulic pump unit, the seal rib is positioned directly along the side of the passageway or forms the inside of a through hole in a plate. The seal rib may be connected to the intermediate layer in a laminated plate.

[0059] Preferably the seal rib protrudes partly above the respective face of the plate, e.g. above the respective back of front layer, whereas the remainder is recessed in the plate. Advantageously, the arrangement of the seal rib partly recessed instead of merely on top of the plate increases a compressibility of the seal rib which improves a sealing property.

[0060] In an embodiment, the function plate and/or any other plate stacked between the main body and the end body, comprises a key to align the plate with respect to the port face of the main body. The main body comprises a complementary key receiver. The configuration of the key receiver is adapted to the configuration of the key to let the key fit to the key receiver. Preferably, the key receiver is positioned at the port face. Preferably, the key of the function plate comprises a key recess at an outer edge of the plate, in which the complementary key receiver comprises a key protuberance which fits in the key recess and which key protuberance is positioned as an outer region of the port face. Advantageously, the presence of the key and complementary key receiver allows

a quick installation of the function plate and/or any other plate. Advantageously, the key of the function plate prevents a misalignment and reversed orientation of the function plate with respect to the port face of the main body.

[0061] In an embodiment the reservoir comprises at least one reservoir opening at an outer planar surface of the main body and wherein the function plate comprises a port region and a reservoir region. The port region is configured to interact with the port face of the main body. In the pump unit, the port region is retained in position parallel to the port face of the main body. The port region includes the at least one slotted passageway. Preferably, the port region further comprises at least one through hole which is in position aligned with a port of the port face of the main body. The reservoir region is configured to interact with the reservoir opening. The reservoir region includes at least one reservoir cut-out which is in an assembly of the pump unit retained in position in alignment with an opening of the reservoir of the pump unit. Advantageously, the configuration of the reservoir region of the function plate allows to introduce predetermined different technical functions with relate to the reservoir, like a filter function or air venting function.

[0062] In an embodiment the reservoir extends at least partly within the main body. The reservoir has at least one reservoir opening in an outer planar surface of the main body that is continuous with the port face of the main body. The function plate is arranged adjoining said port face and said continuous outer planar surface. The function plate comprises a port region and a reservoir region, wherein the port region includes the at least one slotted passageway and is retained in position parallel to the port face, and wherein the reservoir region includes at least one reservoir cut-out in alignment with the at least one reservoir opening in the main body.

[0063] In an embodiment a plate has at least one reservoir cut-out comprises a filter element, in particular a filter material layer, which spans the reservoir cut-out. For example the filter material layer is a layer of a laminated function plate, e.g. an intermediate layer between the front layer and the back layer of plate.

[0064] In an embodiment the reservoir comprises at least two reservoir compartments that each extend at least partly within the main body and each have a respective reservoir opening in the outer planar surface of the main body. The function plate, and possibly one or more other plates, has a respective reservoir cut-out for each reservoir opening. The reservoir compartments are arranged hydraulically in series such that hydraulic passing out of the reservoir opening of one compartment flow through the respective filter element and return through another filter element aligned with the other compartment. For example the hydraulic liquid passing from said one reservoir compartment to a passageway provided in the end body via aligned cut-outs in any throttle plate or connector plate and then back through other aligned cut-outs in any throttle plate or connector plate to said other

reservoir compartment.

[0065] In an embodiment the reservoir region of a plate is encircled by a seal rib on the plate which separates the reservoir region from the port region.

[0066] In an embodiment the reservoir region of a plate further comprises a pump opening for the pump, e.g. the pump partly protruding from the main body at the side of the port face of the main body. In an embodiment the pump opening has a circular shape. The pump opening of the plate is a cut-out which extends from a back side to a front side of the plate.

[0067] In an embodiment the at least one reservoir cut-out is positioned at a circumference and spaced from the pump opening. In particular, two reservoir cut-outs are provided at the circumference and spaced from the pump opening. Preferably, three reservoir cut-outs are provided at the circumference and spaced from the pump opening, wherein the three reservoir cut-outs are aligned with three corresponding reservoir openings which present in the main body, each associated with a respective reservoir compartment, e.g. within the main body.

[0068] In an embodiment the at least one reservoir cut-out comprises a filter element, in particular a filter membrane which spans the reservoir cut-out. The filter element may be arranged to filter passing hydraulic liquid. Preferably, the filter element is arranged to separate air from foaming hydraulic liquid. Preferably, the filter element of one cut-out has a planar filter area of at least 1 cm² for separating the air from foaming passing hydraulic liquid.

[0069] In an embodiment the function plate comprises an air vent for venting air away from the reservoir cut-out. Preferably, the air vent extends from the reservoir cut-out to the pump opening of the plate. Preferably, the air vent is arranged as a shallow groove in a surface of the plate. Advantageously, the air vent allows air which has been separated from the hydraulic liquid by the filter element to be discharged, e.g. to the outer atmosphere.

[0070] In an embodiment the channel system of the main body comprises multiple ducts including multiple intersecting ducts which extend in an axial direction and multiple ducts which extend in a transversal direction of the main body. In an embodiment the multiple ducts are multiple boreholes which are manufactured by drilling, e.g. in a suitable metal, e.g. aluminium, main body.

[0071] In an embodiment, the main body comprises the at least one valve seat, preferably plural valve seat for the same number of valves, e.g. solenoid operated directional valves, e.g. of the cartridge type.

[0072] Instead of mounting a valve block including the at least one valve seat to the main body, the at least one valve seat is preferably incorporated in the main body. The main body including the channel system and the at least one valve seat can be manufactured out of one piece.

[0073] In an embodiment, the main body also comprises the reservoir as an integral part thereof, e.g. the main housing being made of plastic material. Instead of mount-

ing a separate reservoir body to the main body, the reservoir is then incorporated in the main body.

[0074] In an embodiment, the main body comprises a pump recess that houses the pump, e.g. a radial plunger pump. In an embodiment the pump recess includes a cylindrical inner space which extends in the axial direction of the main body. The pump recess preferably extends in a direction in perpendicular to the planar port face of the main body.

[0075] The pump preferably is a rotary driveshaft operated pump, more in particular a plunger pump, preferably a radial plunger pump mounted in a pump recess of the main body.

[0076] The main body including the channel system and the pump recess housing the pump can be manufactured out of one piece, which contributes to an effective mass production of the pump unit.

[0077] In an embodiment of the hydraulic pump unit according to the invention, the pump is partly received in the main body with another part protruding from the main body. The pump recess is configured in correspondence with the dimensioning of the pump housing to receive the inner portion of the pump. Instead of mounting a complete pump inside the pump recess, the pump housing is incorporated in the main body and only an inner portion of the pump is installed in the pump recess.

[0078] In an embodiment, the reservoir comprises a main reservoir which is connected to the pump by a suction flow path which extends from the main reservoir to the pump and wherein the reservoir further comprises at least one reservoir compartment, which reservoir compartment is connected with the main reservoir by a main reservoir flow path. The main reservoir flow path extends in between the reservoir compartment and the main reservoir. In particular, the main reservoir flow path comprises a duct which intersects both the main reservoir and the reservoir compartment. In an embodiment, the duct, in particular a borehole may extend to an outer surface of the main body and may comprise a plug to close the duct at the outer surface. Preferably, the plug is removable to fill the main reservoir with an hydraulic liquid.

[0079] In an embodiment, the main reservoir is fully incorporated in the main body. Preferably, the main reservoir includes a cylindrical body portion which extends in the axial direction of the main body. Preferably, the main reservoir is aligned with a pump recess and is - seen in a frontal view of the pump unit - positioned behind the pump recess. In an embodiment the main reservoir is formed by an extension of a pump recess.

[0080] Preferably, the at least one valve seat, a pump recess housing the pump, and the reservoir are all incorporated in a unitary main body, such that all those features are manufactured out of one piece which allows a reduction of assembly time.

[0081] In an embodiment, the at least one reservoir compartment is incorporated in the main body. Preferably, the at least one reservoir compartment is positioned along an outer circumference of the pump recess in the

main body. Preferably, the at least one reservoir compartment is open at an outer surface of the main body. The at least one reservoir compartment may be closed by a mountable component, like the function plate or end body.

[0082] In an embodiment, the at least one reservoir compartment comprises a filter element, in particular a filter membrane, for filtering a passing hydraulic liquid. Before entering the main reservoir, the hydraulic liquid first passes through the reservoir compartment. The reservoir compartment provides a buffering and flow resistance which mitigates occurring turbulences in the hydraulic liquid. The reservoir compartment provides a low pressure zone. The reservoir compartment contains hydraulic liquid at a relatively low pressure with respect to hydraulic liquid in the channel system of the main body. Any present air contained in the foaming hydraulic liquid will be collected at the reservoir compartment. The filter element of the reservoir compartment advantageously separates air from the hydraulic liquid.

[0083] In an embodiment, the at least one reservoir compartment comprises an air vent. The air vent may be a separate component, like a commonly known hydraulic air vent plug which is mountable to the main body in operable connection with the reservoir compartment. Preferably, the separated air is released out of the reservoir compartment via the air vent to the pump recess. Preferably, the air vent is provided on the function or connector plate by an open passageway. Preferably, the filter element comprises a filter membrane which spans the reservoir compartment and an open passageway is provided as an air vent which extends from the at least one filter compartment to the pump recess. Preferably, the open passageway is positioned upstream and close to the filter membrane. The filter membrane preferably has a large working surface area which contributes to an effective removal of air from the passing hydraulic liquid. The filter membrane may be fixed to the main body, but preferably, the filter membrane is fixed to the function plate or connector plate, in which the filter membrane is spanned across the one or more reservoir cut-outs.

[0084] In an embodiment, the reservoir comprises a first, second and third reservoir compartment. The first, second, third and main reservoir are connected in series by inter-reservoir flow paths. Preferably, the inter-reservoir flow paths are provided on the end body. During operation of the pump unit, the hydraulic liquid passes through the reservoir compartments before entering the main reservoir. The first and second reservoir compartments comprise an air vent and serve to stabilise the hydraulic liquid and to separate air from the liquid.

[0085] In an embodiment, the third reservoir compartment is connected in series with the first reservoir. The third reservoir compartment serves to receive a flow of hydraulic liquid in case that a predetermined pressure is exceeded. The third reservoir compartment comprises at least one flow path provided with a pressure relief valve. Preferably, the third reservoir compartment is pro-

vided with a filter element two separate air from a passing hydraulic liquid.

[0086] In an embodiment, the pump unit further comprises a throttle plate. The throttle plate comprises at least one throttle orifice. The throttle orifice is open from a back side to a front side of the throttle plate. In an embodiment, the throttle orifice is positioned in the throttle plate in alignment with a port of the port face of the main body. The throttle plate is preferably mounted in the pump unit in combination with the function plate and possibly a connector plate as will be described later herein. The throttle plate is retained in position in parallel with the port face. In an embodiment the throttle plate is mounted directly against the port face. In an alternative embodiment, the throttle plate is mounted against a function plate which in turn is mounted directly against the port face. The function plate is then positioned in between the throttle plate and the port face of the main body.

[0087] In a particular embodiment, which may constitute the first aspect of the invention, the pump unit may be arranged without a function plate, but including a throttle plate as described herein. Advantageously, the throttle plate may be selected from a set of different throttle plates to obtain a desired throttling property at one or more locations in a hydraulic circuit embedded in the pump unit.

[0088] The one or more throttle orifices in the throttle plate are each sized to provide a predetermined throttling of passing hydraulic liquid. The required throttling might be determined by experiments with a hydraulic actuating device operating in a practical environment, e.g. when testing a prototype of a hydraulic actuating device under real conditions, e.g. a convertible roof actuating device.

[0089] The throttle plate is preferably made of metal or other hard material, so that wear of the throttle orifices is avoided. The orifices can e.g. be made by waterjet or laser cutting.

[0090] The throttle plate provides an advantage in that the throttle plate can be replaced by another throttle plate in case that other throttling properties are desired.

[0091] In comparison with the known hydraulic pump unit from WO2010/127744, the proposed throttle plate is advantageous, because the throttle plate allows in a simple manner to achieve an accurate throttling of one or more flows of hydraulic liquid within the circuit.

[0092] In an embodiment, a single throttle orifice, e.g. to be aligned with a hole in an adjacent function plate, comprises a plurality of tiny apertures that also serve as a fine filter for passing hydraulic liquid. The filtering apertures are grouped and positioned close to each other to obtain an alignment with a port of the port face of the main body or a hole of an abutting function or connector plate. In particular, a single throttle orifice may comprises at least five, more in particular at least ten apertures. The filtering apertures are preferably sized in a micrometre range. In particular, the filter apertures may each have a diameter of at most 100 μm , in particular at most 50 μm , preferably at most 20 μm . Advantageously, the throttle

orifice including the filter apertures serves to obtain a predetermined throttling in a flow path and further serves to filter contaminations out of a passing hydraulic liquid.

[0093] Preferably, the throttle plate comprises at least one bolthole, a key receiver and/or at least one seal rib around each individual throttle orifice as described above with respect to the function plate.

[0094] In an embodiment, the pump unit further comprises a connector plate. The connector plate is retained in position in parallel with the port face of the main body. The connector plate is retained in position in parallel with the end body port face. The connector plate is arranged in abutting engagement with the end body. The connector plate serves to connect flow paths provided on the end body with flow paths provided on the main body via the one or more intermediate plates that are sandwiched between the end body and the main body.

[0095] In an embodiment, the connector plate is embodied as a second function plate. The connector plate may have the same structure and provide the same functionality as described herein for the function plate. An embodiment of the connector plate may include the same features as the above described function plate.

[0096] In an embodiment, the connector plate comprises at least one bolthole for introducing a bolt to mount the end body to the main body.

[0097] In an embodiment, the connector plate comprises at least one hydraulic liquid connector hole, e.g. which is positioned in alignment with a port of the port face of the end body.

[0098] In an embodiment, the connector plate comprises a key receiver and/or at least one seal rib around each connector hole as described above with respect to the function plate.

[0099] In an embodiment, the connector plate comprises a plurality of connector holes which each extend through the connector plate. In an embodiment the connector plate is configured without a slotted passageway.

[0100] Each connector hole is preferably provided with its own seal rib.

[0101] Advantageously, this simple configuration of the connector plate allows a simple configuration of a pump unit to obtain a particular hydraulic circuit.

[0102] In an embodiment of the hydraulic pump unit according to the invention, the connector plate further comprises at least one slotted hydraulic liquid passageway, e.g. connecting at least two connector holes, such that a flow path of the hydraulic circuit is determined.

[0103] The connector plate according to the invention can be arranged similar to a function plate with an individual configuration of one or more through holes and one or more slotted passageways in accordance with a predetermined hydraulic circuit to be provided. Herewith, the connector plate is configured similar to the above described function plate and may serve as an additional function plate.

[0104] In an embodiment the pump is a radial plunger pump having a housing with a two ports, e.g. one acting

as suction port sucking in hydraulic fluid and a delivery port delivering pressurized hydraulic fluid. In an embodiment the plunger pump is embodied for reversible operation wherein the ports change their function dependent on the direction of rotation of the plunger pump.

[0105] In general a plunger pump has a stator part which comprises a pintle with two ducts therein for hydraulic liquid. These ducts extend through the pintle and are respectively in communication with the ports in the housing of the pump. A rotor is arranged rotatable about the projecting section of the pintle. The rotor is provided with multiple radial bores, in each of which a plunger can slide in a reciprocating fashion. The plungers bear against a running surface that is circular and eccentrically with respect to the pintle, e.g. the inner race of a ball bearing. The plungers may have a small diameter, e.g. between 2 and 6 millimeters, e.g. for use in a small hydraulic power pack application of the pump unit. For example the diameter of each piston may be in a range between 1.5 millimeter and 2.8 millimeter. The circular running surface may be formed eccentrically such that the length of each piston is larger than the diameter of the respective piston, wherein the length of the piston lies in a range between 3 millimeter and 6 millimeter.

[0106] In an embodiment, the pump unit comprises a stack of plates, wherein each plate is selected from a group including at least one function plate, at least one throttle plate and/or at least one connector plate. The plates of a stack are selected to obtain a pump unit with a predetermined hydraulic circuit.

[0107] Preferably, each plate of the stack is provided with a key receiver which is complementary shaped to a key positioned at the main body. Advantageously, the presence of the key receiver assures a correct placement of each individual plate in the stack and an alignment of the stack with respect to the ports of the port face of the main body.

[0108] In an embodiment, the pump unit comprises a pump motor. The motor is preferably an electrical drive motor which is connected to the pump, preferably the pump has a rotary output shaft. Preferably, the motor is of a type which has a substantially constant maximum power output which it can deliver as a function of a rotational speed.

[0109] Further embodiments are defined in the subclaims and the description of the figures.

[0110] Further, the invention relates to a function plate, a throttle plate, a connector plate and a stack of plates, which plates are selected from a group, wherein each plate is selected from a group including at least one function plate, at least one throttle plate and/or at least one connector plate including technical features as described above with respect to the pump unit.

[0111] Further, the invention relates to a hydraulic actuating device which comprises at least one hydraulic actuator, in particular a set of motion independent hydraulic actuators. The at least one hydraulic actuator is operable connected in a hydraulic circuit which compris-

es a pump unit according to invention.

[0112] Further, the invention relates to a method of producing a actuating device comprising a step of producing a first actuating device defining a first hydraulic circuit which has a generic and specific hydraulic circuit part and producing a second actuating device defining a second hydraulic circuit which has a generic and specific hydraulic circuit part, characterised in that the specific hydraulic circuit part of each actuating device is defined by a function plate, wherein the function plate comprises at least one slotted hydraulic liquid passageway which extends across the function plate.

[0113] Further, the invention relates to a method of assembling a hydraulic pump unit to obtain a predetermined configuration of a hydraulic circuit to operate a set of motion independent hydraulic actuators. Motion independent means that at least one hydraulic actuator is provided to move independent from another hydraulic actuator. The method comprises several steps. In a step of the method, a hydraulic pump unit according to the invention is provided in an un-assembled configuration. In a step of the method, a function plate is selected which comprises at least one slotted passageway which is configured to provide a predetermined flow path of the hydraulic circuit. In a step of the method, the function plate is aligned with the port face of the main body of the hydraulic pump unit. In a step of the method, the ends body of the pump unit is mounted to the main body, wherein the function plate is sandwiched in between the end body in the main body. After a correct placement of the components, the end body, the function plate and the main body are assembled together.

[0114] In an embodiment of the method according to the invention, the method further comprises a step of selecting a throttle plate. The throttle plate is selected based on a particular configuration of a throttle orifice to obtain a specific throttling at a specific flow path of the hydraulic circuit. The throttle plate is stacked with the function plate and mounted to the main body. The throttle plate may be stacked and positioned at a backside of the function plate, such that the throttle plate is in an assembled configuration of the pump unit placed in between the main body and the function plate. Alternatively, the throttle plate may be positioned at the front side of the function plate, such that the function plate is in an assembled configuration of the pump unit placed in between the function plate and the end body. Preferably, the throttle plate is positioned in between the function plate and the end body of the pump unit which allows an arrangement of the throttle plate without a sealing.

[0115] In an embodiment of the method according to the invention, the method further comprises a step of selecting a connector plate. The connector plate is selected based on a particular positioning of at least one connector hole which is in alignment with a port of the port face of the main body. By selecting a connector plate, a connection is provided with a port of the port face, such that a flow path of the hydraulic circuit is obtained. After

selecting the connector plate, the connector plate is stacked with the function plate and mounted to the main body of the pump unit.

[0116] According to a third and fourth aspect of the invention, the invention relates to a hydraulic pump unit comprising a pump, in particular a rotary drive shaft operated pump, a reservoir for hydraulic liquid, multiple line connectors for connecting the set of hydraulic actuators to the pump unit via actuator lines, and at least one valve seat, wherein an electrically operable valve is or can be installed at the at least one valve seat. Further, the hydraulic pump unit comprises a main body including a channel system for the hydraulic liquid. The channel system comprises multiple ducts which interconnect the pump, the reservoir and the at least one valve seat. Each duct forms a flow path of a hydraulic circuit. The channel system includes ducts which have duct ends which are situated in a surface of the main body. The duct ends define multiple ports in a common port face.

[0117] According to the third aspect of the invention, the reservoir comprises a main reservoir which is connected to the pump by a suction flow path which extends from the main reservoir to the pump and at least one reservoir compartment, which reservoir compartment is connected with the main reservoir by a main reservoir flow path.

[0118] In an embodiment of the pump unit according to the invention, the main reservoir and the at least one reservoir compartment are incorporated in the main body and wherein the at least one reservoir compartment has a reservoir opening at an outer surface of the main body.

[0119] In an embodiment of the pump unit according to the invention, the at least one reservoir compartment comprises a filter element for filtering a passing hydraulic liquid.

[0120] In an embodiment of the pump unit according to the invention, the filter element comprises a filter membrane which spans the at least one reservoir compartment.

[0121] In an embodiment of the pump unit according to the invention, the reservoir comprises a first, second and third reservoir compartment, wherein the first, second, third reservoir compartments are connected in series by inter reservoir flow paths, such that in operation a liquid passes first through the reservoir compartments and then enters the main reservoir.

[0122] According to the fourth aspect of the invention, the pump comprises a pump housing and an inner portion, wherein the pump housing is incorporated in the main body of the pump unit.

[0123] So far the explanation of the second, third and fourth aspect of the invention. It will be clear that these aspects can be applied in combination with each other and in particular with the first aspect, but may also equally well be used separately from the first aspect. The above described embodiments with respect to the first aspect include features which can also be applied in combination with the second, third and fourth aspect of the invention.

Features of the aspects of the invention are described in further detail with reference to the drawings hereafter.

[0124] The invention will be explained in more detail with reference to the appended drawings. The drawings show a practical embodiment according to the invention, which may not be interpreted as limiting the scope of the invention, in which:

Fig. 1 shows in side view an embodiment of hydraulic pump unit according to the invention including an electric pump drive motor, as well as connected actuator lines,

Fig. 2 shows a perspective view of the pump unit of figure 1;

Fig. 3 shows another perspective view of the pump unit of figure 1;

Fig. 4 shows the hydraulic pump unit of figure 1 in perspective view with the electric operable valves removed from their seats;

Fig. 5 shows the pump unit of figure 1 in a cross-sectional view along an axial axis with a central valve removed from the seat;

Fig. 6 shows the pump unit of figure 1 in an exploded view;

Fig. 7 shows a main body of the pump unit of figure 1 including the pump and three valves;

Fig. 8 shows in perspective view the pump of the unit of figure 1;

Fig. 9 shows a longitudinal section of the pump of figure 8;

Fig. 10 shows the main body of figure 7 with the pump removed;

Fig. 11 shows a top view of the main body of figure 7;

Fig. 12 shows a longitudinal cross section of the main body with the pump removed;

Fig. 13 shows in a frontal view on the port face of the main body of figure 7;

Fig. 14 shows a function plate of the pump unit in a perspective view;

Fig. 15 shows the function plate of figure 14 from the other side;

Fig. 16 shows in an enlarged view and in cross-section the laminated function plate of figure 14 and 15;

Fig. 17 shows in a perspective view a throttle plate of the pump unit of figure 1 in a perspective view;

Fig. 18 shows a side view of the throttle plate of Fig. 17;

Fig. 19 shows a front view of the throttle plate of Fig. 17;

Fig. 20 shows a connector plate of the pump unit of figure 1 in a perspective view;

Fig. 21 shows the connector plate of fig. 20 in another perspective view;

Fig. 22 shows the end body of the pump unit of figure 1 in a perspective view;

Fig. 23 shows the end body of figure 22 in another perspective view;

Fig. 24 shows the side of the end body of figure 22

with the line connectors and the motor mount;

Fig. 25 shows the side with the port face of the end body of Fig. 22;

Fig. 26 shows in a schematic view a layout of a first hydraulic circuit including layout-sections which correspond with components of the pump unit according to the invention;

Fig. 27 shows in a layout of a second hydraulic circuit which is provided by a pump unit in which several components include a different configuration of features with respect to the components as shown in Fig. 26 to obtain the different second hydraulic circuit;

Fig. 28 shows a perspective view of an embodiment of a pump unit having an end body out of two end body parts;

Fig. 29 shows a side view of the pump unit as shown in fig. 28;

Fig. 30 shows a top view of the pump unit as shown in fig. 28;

Fig. 31 shows a perspective front view of a sub-assembly including a first end body part, a connector plate, a throttle plate and a function plate;

Fig. 32 shows a perspective back view of the sub-assembly as shown in fig. 31;

Fig. 33 shows a perspective view of a subassembly including a connector plate, a throttle plate and a function plate; and

Fig. 34 shows a perspective view of the throttle plate from the subassembly as shown in fig. 33.

[0125] The invention and aspects thereof will now be described, in non-limiting manner, with reference to the drawings.

[0126] Identical reference signs are used in the drawings to indicate identical or functionally similar components.

[0127] The hydraulic pump unit 1 is configured for supplying pressurised hydraulic liquid, e.g. at pressures of tens of bars, or even above 100 bars, to a set of hydraulic actuators.

[0128] The set of hydraulic actuators, see e.g. figures 26, 27, comprises a plurality of actuators, in which a first actuator may be arranged to move independently from a second actuator, e.g. the one actuator operating one element of a convertible roof system and the other actuator another element of said system. An actuator may herein also be a pair of parallel actuators that are operated in synchronicity. For example, the first actuator is at the same moment able to move about a different stroke or speed than the second actuator.

[0129] The hydraulic pump unit 1 comprises a main body 5, a rotary drive shaft operated pump 2, a drive motor 10, and a reservoir 3 for a hydraulic liquid. An end body 9 is provided with multiple line connectors 99 for connecting actuator lines 104 to the unit 1, e.g. flexible hydraulic hoses with end connector fittings that can be connected to the connectors 99, e.g. inserted therein.

The lines 104 connect the unit to a set of hydraulic actuators.

[0130] The main body 5 of unit 1 has at least one, here three, valve seats 40. In each seat an electrically operable, e.g. solenoid operable, hydraulic control valve 4 is mounted, e.g. a directional valve.

[0131] The main body 5 includes a channel system 50 that conducts the hydraulic liquid. The channel system 50 interconnects the pump 2, the reservoir 3, and the at least one valve seat 40. The channel system 50 comprises multiple ducts 501. The channel system 50 includes ducts which have duct ends 502 situated in an outer surface of the main body 5, which duct ends 502 define multiple ports 52 in a common port face 51. The port face 51 of the main body 5 is a planar face of the outer surface.

[0132] The depicted pump unit 1 further comprises a function plate 6, a throttle plate 7, a connector plate 8. As disclosed the number and type of plate in the unit may be varied to achieve other arrangements.

[0133] The plates 6,7,8 form a stack that is sandwiched between the end body 9 and the main body 5.

[0134] The function plate 6 comprises at least one slotted passageway 60. The slotted passageway 60 extends across the function plate 6. The function plate 6 is retained in position parallel to the port face 51 such that the slotted passageway 60 mates with at least two ports 52 of the port face 51 to define a flow path in between these ports 52.

[0135] The end body 9 sandwiches the function plate 6 between the port face 51 of the main body 5 and the end body 9 itself, here with interposition of the other plates 7, 8.

[0136] The channel system 50 of the main body and the function plate 6 and connector plate 9 together determine the effective hydraulic circuit of the pump unit 1. The throttle plate 7 is dedicated to providing throttle orifices where required in the circuit.

[0137] The hydraulic pump unit 1 provides an advantage in that a desired lay-out function plate 6 can be mounted and by providing a set of different plates 6 one can easily assemble, with the main bodies 5 being identical, units 1 with different hydraulic circuits, e.g. allowing to drive different system with sets hydraulic actuators.

[0138] The function plate 6 is mounted directly onto the planar port face 51 which is situated at an outer surface of the main body 5. The planar shape and the situation of the port face 51 at an outer surface contributes to a simple assembly.

[0139] The hydraulic pump unit 1 will be described with reference to a spatial relation of the components of the pump unit. The pump unit 1 is described in a spatial orientation in which the main body 5 is positioned at a back side B of the pump unit and in which the end body 9 is positioned at a front side F of the pump unit 1. A reference to an axial direction of the pump unit 1 means a reference to a linear direction along a centre line which extends from the back side B to the front side F of the pump unit.

[0140] Figure 5 shows the hydraulic pump unit 1 in a

cross-sectional view in which the reservoir 3 inside the main body 5 is visible. The reservoir 3, here the main reservoir 30, is aligned with the pump 2 that is housed within recess 56 of the main body 5.

[0141] A motor 10 is integrated in the unit 1 and is adapted to drive the pump 2. The motor 10 here is mounted to the end body 9, opposite the main body 5. The end body has a portion embodied as a motor mount 98 for the motor 10. Here the motor 10 is positioned at an opposite side of the pump 2 with respect to the reservoir 3.

[0142] The motor 10 has a rotatory output shaft 11, that protrudes into and through the end body 9. The shaft 11 is coupled to the pump 2, here a radial plunger pump 2. It is envisaged that the pump 2 may be a reversible pump wherein the direction of hydraulic flow is reversed by reversing the direction of rotation of the output shaft 11 of the motor 10.

[0143] A stack of plates 6, 7, 8 is sandwiched in between the main body 5 and the end body 9. The stack of plates comprises the function plate 6 and additionally a throttle plate 7 and a connector plate 8. The stack is clamped under significant pressure in between the end body 9 and the main body 5 to achieve a leak tight engagement of all interfaces, e.g. by a bolt connection between the end body 9 and the main body 5.

[0144] Fig.6 shows the hydraulic pump unit 1 in an exploded view in which the function plate 6, the throttle plate 7, and the connector plate 8 are shown in further detail. In a preferred sequence of the throttle and function plate of the package, the function plate 6 is positioned behind the throttle plate 7. The function plate 6 is positioned behind the throttle plate 7 to be placed against the port face 51 of the main body 5. The connector plate 8 is positioned in front of the stacked throttle plate 7 and function plate 6, such that the connector plate 8 is placed against the end body 9.

[0145] The function plate 6 and connector plate 8 are provided with one or more seals, e.g. sealing ribs, at the front side and the back side of the plate to prevent leakages of hydraulic liquid. The throttle plate 7 is sandwiched in between the function and connector plate 6,8 and may, preferably is, arranged without a seal.

[0146] The pump 2 which is mounted at front side F of the main body 5 and three control valves 4 which are mounted at a top side T of the main body 5.

[0147] At the front side F, the outer surface of the main body 5 comprises a planar outer surface which includes the common port face 51. The port face 51 comprises a plurality of ports 52 which are formed by the duct ends 502 of the ducts 501 in the main body 5 which form the channel system 50.

[0148] The main body 5 comprises a pump recess 56 wherein the pump 2 is housed.

[0149] The pump recess 56 includes a cylindrical inner space which extends in the axial direction of the main body 5. The pump recess 56 extends in a direction in perpendicular to the planar port face 51 of the main body. The pump 2 is mountable in the pump recess 56 of the

main body 5 by inserting the pump 2 therein.

[0150] In particular the pump 2 is a plunger pump, more in particular the pump 2 is a radial plunger pump as will be explained by example with reference to figures 7, 8, and 9.

[0151] The pump is a radial plunger pump 2 having a housing 26 with a two ports 26a, 26b, e.g. one acting as suction port sucking in hydraulic fluid and a delivery port delivering pressurized hydraulic fluid. In an embodiment the plunger pump 2 is embodied for reversible operation wherein the ports change their function dependent on the direction of rotation of the plunger pump.

[0152] In general a plunger pump has a stator part which comprises a pintle 22 with two ducts 22a therein for hydraulic liquid. These ducts extend within the pintle 22 and are respectively in communication with the ports 26a, 26b in the housing of the pump. A rotor 20 is arranged rotatable about the projecting section of the pintle 22. The rotor 20 is provided with multiple radial bores 27, in each of which a plunger 23 can slide in a reciprocating fashion. The plungers 23 bear against a running surface that is circular and eccentrically with respect to the pintle 22, e.g. the inner race of a ball bearing 21. The plungers 23 may have a small diameter, e.g. between 2 and 6 millimeters, e.g. for use in a small hydraulic power pack application of the pump unit. For example the diameter of each piston may be in a range between 1.5 millimeter and 2.8 millimeter. The circular running surface may be formed eccentrically such that the length of each piston is larger than the diameter of the respective piston, wherein the length of the piston lies in a range between 3 millimeter and 6 millimeter.

[0153] The rotor 20 is provided with a coupling, here a pin 28, to connect the rotor 10 to the shaft 11 of the motor 10, e.g. via an coupling disc 16 on the shaft 11.

[0154] The main body 5 further comprises at least one valve seat that allows to install therein a hydraulic liquid flow control valve 4, e.g. a directional valve and/or a proportional valve, e.g. a solenoid operated valve.

[0155] The at least one valve seat 41, 42, 43 here is provided at the top side T of the main body 5.

[0156] The main body 5 here has three valve seats, a first valve seat 41, a second valve seat 42, and a third valve seat 43.

[0157] The at least one valve seat is incorporated in the main body 5. The main body 5 including the channel system 50, the pump recess 56 and the at least one valve seat 40 is a one piece item. The unitary main body 5 can be manufactured by milling and drilling operations, e.g. from a block of metal, e.g. of aluminium. Other manufacturing methods are also possible, e.g. injection moulding or other technologies for making plastic components, e.g. when making the main body of plastic material.

[0158] Figures 5 and 12 show the channel system 50 in further detail. The channel system 50 includes multiple ducts 501, e.g. some of which extend in an axial direction. Axially extending ducts 501A comprise duct ends which form the ports 52 of the port face 51. Further, the channel

system 50 includes multiple ducts 501T which extend in a transversal direction. The channel system 50 comprises intersecting ducts 501 which define flow paths of the hydraulic circuit.

5 **[0159]** The planar face of the main body 5 comprises the port face 51 with the ports 52.

[0160] The main body 5 comprises an alignment key 53 which is configured to align a component of the pump unit which is mounted in front of the port face 51 to the main body 5. The key 53 comprises a key protuberance which protrudes with respect to the port face 51. The key 53 is positioned as an edge of the port face 51.

10 **[0161]** The main body 5 further incorporates the reservoir 3 of the pump unit 1. The reservoir 3 serves to contain a volume of hydraulic liquid. The reservoir 3, in particular a main reservoir 30 thereof, here is positioned in alignment with the pump recess 56. The pump 2 is positioned at a front side region of the unit 1. The reservoir 3 is positioned at a back side region of the pump unit 1.

15 **[0162]** The reservoir 3 here comprises a cylindrical inner space which is an extension of the pump recess 56 in the main body 5. Further, the main body 5 comprises a fill opening 59 which is provided with a plug 58 for filling the reservoir 3 with hydraulic liquid.

20 **[0163]** In the example shown the reservoir 3 comprises the main reservoir 30 and at least one additional reservoir compartment. Here, the reservoir 3 comprises a first reservoir compartment 31, a second reservoir compartment 32, and a third reservoir compartment 33. The reservoir compartments 31, 32, 33 are here distributed about the pump recess 56 and spaced therefrom and separated by compartment wall parts of the main body.

25 **[0164]** The first reservoir compartment 31 is positioned at a left side L of the pump recess 56. The second reservoir compartment 32 is positioned below, at side D, of the pump recess 56. The third reservoir compartment 33 is positioned at a right side R of the pump recess 56.

30 **[0165]** The reservoir compartments 31, 32, 33, each extend in the axial direction, starting from an opening in the planar outer surface and then into the main body 5.

35 **[0166]** The reservoir compartments 31, 32, 33 are each open at the planar outer surface at the front side F of the main body. Each reservoir compartment 31, 32, 33 has a reservoir opening 311, 312, 313 in said planar outer surface. The reservoir opening has preferably a dimension similar to the transverse cross-section of the respective reservoir compartment.

40 **[0167]** Each reservoir opening is positioned in a reservoir region 54 of the planar face at the outer surface of the main body 5, which region 54 is a continuation of the planar common port face 51, which is said to fall in a port region 510 of the entire planar outer face of the main body 5.

45 **[0168]** The main body 5 further comprises a plurality of holes 57 to receive fasteners 14, e.g. bolts, that pull the end body towards the main body with the sandwiched

plates 6,7,8 in between. In this example the holes 57 are threaded holes 57 into which bolts 14 can be mounted. For example the end body is connected by at least four bolts 14 to the main body, here by six bolts 14. Four holes 57 may be arranged around the port face 51 to achieve the desired compressional force.

[0169] The function plate 6 comprises a plurality of bolt-holes 67 for the bolts or other fasteners 14. The bolt-holes 67 are aligned with the holes 57 of the main body 5.

[0170] The function plate 6 has a front side and a back side. A registration code may be provided at a front side of the function plate 6.

[0171] The function plate 6 here has a rectangular outer contour. The function plate 6 is provided with rounded corners and has substantially straight edges.

[0172] The function plate 6 may have a thickness of at most 5 mm, e.g. less than most 3 mm. Preferably, the function plate has a thickness of about 1mm.

[0173] The function plate 6 comprises a key receiver 53'. The key receiver 53' is configured to receive the alignment key 53 which is provided at the main body 5. The key receiver 53' is configured to align the function plate 6 with respect to the port face 51 of the main body 5. The key receiver 53' is positioned at an edge of the function plate 6. The key receiver 53' comprises a key recess which is sized to receive the key protuberance of the alignment key 53. The key 53 fits inside the key recess.

[0174] The function plate 6 is shown here as a laminated plate. The connector plate 8 has a similar laminated structure.

[0175] The laminated plate 6, 8 comprises three main layers. Lamination means that these three layers are stacked and fixed together about substantially an entire contact surface to obtain a one piece item. A lamination process may include a step of thermo binding or gluing, or a technique like injection moulding.

[0176] At the back side, the laminated function plate 6 comprises a back layer 60B. At the back layer holes are visible which are to be aligned with respective ports 52 of the port face 51 of the main body 5.

[0177] At the front side, the laminated function plate 6 comprises a front layer 60F. The front layer shows the holes 61 that extend through the plate and it here shows at least one slotted hydraulic liquid passageway 60.

[0178] In between the back and front layer, the laminated function plate 6 or plate 8 comprises an intermediate layer 60I.

[0179] The front and back layer 60F,60B preferably comprise a plastic material. If desired one or both of the front and back layer can be moulded, e.g. injection moulded, to the intermediate layer 60I.

[0180] Here, the intermediate layer 60I comprises a filter element, in particular the layer is formed by a filter membrane. Preferably, the filter membrane comprises a woven material, e.g. of suitable plastic material or of metal.

[0181] In an embodiment the intermediate layer 60I

comprises a support sub-layer for supporting the filter membrane.

[0182] The slotted passageway 60 is provided as a groove in a front layer or back layer of the plate, here in the front layer 60F of the function plate 6. The groove 60 here extends in between at least two holes 61 through the function plate. The front layer 60F shows through holes 61 of the function plate 6. The groove in the front layer between the through holes 61 has a groove depth which is smaller than the thickness of the laminated function plate 6, in particular a depth less than or at most equal to the thickness of the respective layer, here front layer 60F.

[0183] Then filter layer 60I preferably spans each hole 61 through the plate, to obtain a filter function by the filter membrane of the intermediate layer 60I.

[0184] In an embodiment a passageway 60 is not formed as a groove in the body of the plate but as a trough the plate type passageway which is open from the back to the front side of the plate. Or, when a multilayer plate is employed, a groove may be made as a through one layer type passageway. This approach allows a manufacturing of passageway by processes like waterjet cutting, punching, etc. which may be cost effective in a mass production.

[0185] In an embodiment the groove in a layer which forms the passageway 60 connects to one or more through holes that extend through the plate, e.g. the groove has a groove end which is formed by a through hole.

[0186] The groove end may have a depth which is equal to the thickness of the respective layer. A groove section in between groove ends may have a reduced depth with respect to the groove ends or any location where the groove is joined to a hole 61. The depth of the groove section which forms the passageway 60 may be smaller than a thickness of the respective layer, e.g. front layer 60F. For example the groove may be manufactured by moulding the respective layer from plastic material, e.g. before the layer is laminated to the intermediate layer 60I.

[0187] The front layer 60F, the intermediate layer 60I, and the back layer 60B are laminated to form a one piece function plate 6. The same structure is envisaged for plate 8.

[0188] The intermediate layer 60I comprises the filter membrane 68. The filter membrane 68 substantially forms the whole intermediate layer 60I. The intermediate layer 60I further may comprise a support sub-layer for supporting the filter membrane 68. The filter membrane 68 provides filter membrane sections positioned to span each of the holes 61 and the at least one reservoir cut-out 65 when present in the plate.

[0189] In a step of manufacturing the function plate, the membrane 68 may be connected to the support sub-layer and then laminated to the front and back layer 60F, 60B. Locally, at a position of a hole 61 of the function plate 6, the front and back layer 60F, 60B are both locally

open from a back side to a front side and the support sub-layer of the intermediate layer 601 is also locally open which provides a filter membrane at the hole 61.

[0190] The function plate 6 is provided with seals 62 at the front and back side 6F, 6B. The seals 62 are arranged to seal the function plate 6 with respect to an abutting component which is here the main body 5 and the throttle plate 7.

[0191] The seals 62 are permanently affixed to the function plate 6 as is preferred. Preferably the seals 62 extend partly beyond a face of the plate, and preferably a portion of the seals is recessed into the plate or plate layer.

[0192] In an embodiment the seals 62 comprises a compressible seal material, e.g. a silicone or (synthetic) rubber material.

[0193] In an embodiment the seals 62 are vulcanised onto the plate. In another embodiment the seals 62 are made by 2K injection moulding of the plate, or layer thereof, e.g. simultaneous forming the one or more passageways, e.g. as a groove in the plate or layer. The seals 62 can also be provided as an insert that is moulded in a plastic plate or plate layer.

[0194] The seal 62 is positioned encircling a respective passageway 60 or hole 61 of the function plate 6, preferably recessed into the plate to form a side wall of the passageway or hole, or at least a part of said side wall. The recessing increases the height of the seal which provides flexibility to the seal 62 to let the seal 62 to be compressed when the function plate is sandwiched in between the end and main body 9, 5.

[0195] The seals 62 may comprise a plurality of seal ribs 621, 622. The seal ribs are positioned at a port region 610 of the function plate 6 which port region 610 includes a plurality of holes 611, 612 and slotted passageways 601, 602. The holes and passageways of the function plate 6 are provided to define flow paths of the hydraulic circuit which is embedded in the hydraulic pump unit. After connecting the function plate 6 to the main body 5, the layout of the slotted passageway 601, 602 determines a particular liquid connection in between ports 52 in the port face 51 of the main body 5. This liquid connection in between the respective ports forms a particular flow path which determines the hydraulic circuit of the pump unit 1.

[0196] A reservoir region 64 of the function plate 6 may be separated from the port region 610 by a seal rib 623. The seal rib 623 encircles the reservoir region 64.

[0197] The function plate 6 here has a first, second and third reservoir cut-out 651, 652, 653 corresponding to the reservoir compartments having openings in the outer planar face of the main body 5. Each reservoir cut-out provides an open through flow from the back side to the front side of the function plate 6. The first, second and third reservoir cut-out 651, 652, 653 are positioned in the reservoir region 64. The first, second and third reservoir cut-outs 651, 652, 653 are aligned with the first, second and third reservoir compartments 31, 32, 33 situated at the

main body 5. The first, second and third reservoir cut-outs are sized in correspondence with the openings 311, 312, 313 of the first, second and third reservoir compartment of the reservoir 3.

[0198] Here, the first, second and third reservoir cut-outs 651, 652, 653 of the function plate 6 are provided with a filter membrane section 68. The filter membrane 68 has a first, second and third filter membrane section 681, 682, 683 in which each section spans the reservoir cut-out. The filter membrane section is preferably formed by the filter membrane 68 of the intermediate layer 601.

[0199] The function plate 6 further comprises the pump opening 66 for the pump 2 which is mounted in the pump recess 56 of the main body 5. Here the pump opening 66 has a circular shape in cross-section. The pump opening 66 is positioned at a central position in the reservoir region 64 of the function plate. The pump opening 66 is positioned in between the first and third reservoir cut-out 651, 653.

[0200] The first and second reservoir cut-outs 651, 652 here comprise an air vent 661, 662. The air vents 661, 662 serve to discharge air that has been separated by the filter membrane from the passing hydraulic liquid. The air is discharged from the reservoir compartment 351, 352, here to the pump recess 56, in particular to the pump opening 66. Preferably, the air vent 661, 662 is formed by an open passageway. The open passageway is positioned upstream and close to the filter membrane 68.

[0201] The throttle plate 7 has a front side 7F and a back side 7B. The throttle plate 7 here has a rectangular outer contour. The throttle plate 7 is provided with rounded corners and has substantially straight edges. The throttle plate 7 has substantially the same outer dimensions as the function plate 6. The throttle plate 7 is stackable with the function plate 6 to form a stack.

[0202] The throttle plate 7 comprises a plurality of bolt-holes 77 for the bolts 14. The bolt-holes 77 are aligned with the holes 57 of the main body 5.

[0203] The throttle plate 7 comprises a key receiver 53'. The key receiver 53' is configured to receive the key 53 which is provided at the main body 5. The key receiver 53' is configured to align the throttle plate 7 with respect to the port face 51 of the main body 5. The key receiver 53' is positioned at an edge of the throttle plate 7. The key receiver 53' comprises a key recess which is sized to receive the key protuberance of the key 53. The key 53 fits inside the key recess.

[0204] The throttle plate 7 comprises at least one throttle orifice 70. The at least one throttle orifice 70 may be positioned in alignment with a port 52 of the port face 51 of the main body 5. The at least one throttle orifice 70 is a through hole which is small with respect to a diameter of a port 52.

[0205] The at least one throttle orifice 70 is sized to provide a throttling in the hydraulic circuit of the pump unit 1. The presence of the throttle orifice 70 provides a particular throttling in a flow path of the hydraulic circuit.

[0206] The at least one throttle orifice 70 may have a diameter of at least 0, 1 mm to at most 3 mm, in particular at most 2 mm, but preferably at most 1 mm, e.g. between 0.2 and 0.8 mm.

[0207] Further, the throttle plate 7 comprises a hole 71 which is positioned in alignment with a port 52 of the port face 51 of the main body 5. The hole 71 has a diameter which is substantially equal to the diameter of the port 52. The hole 71 provides a through flow for a hydraulic liquid without throttling effect.

[0208] A single throttle orifice 70 may comprise a group of apertures 73 that have very tiny diameters, so that the apertures also act as fine filter for passing hydraulic liquid. The apertures are grouped together at a local position, which local position is e.g. aligned with a port 52 of the port face 51 of the main body 5.

[0209] In an embodiment an individual throttle orifice 70 comprises a group of at least 5 small diameter apertures, in particular at least 10 apertures. The apertures are preferably sized in the micrometre range. In an embodiment the apertures may each have a diameter of at most 100 μm , in particular at most 50 μm , but preferably at most 20 μm . A total open area of the group of apertures determines the throttle property of the orifice, while an open area of an individual aperture determines a filter property.

[0210] In its planar face, the throttle plate 7 comprises an imaginary port region 710 and an imaginary reservoir region 74. The port region of the throttle plate 7 here is positioned at a top region and comprises the at least one throttle orifice 70. The at least one throttle orifice 70 is positioned in the port region 710. The reservoir region 74 is positioned below the port region 710. The reservoir region 74 of the throttle plate 7 corresponds with the reservoir region 64 of the function plate 6.

[0211] The throttle plate 7 here also comprises a first, second and third reservoir cut-out 751, 752, 753. The reservoir cut-out provides an open, non-filtered, through flow from the back side to the front side of the throttle plate 7. The first, second and third reservoir cut-out 751, 752, 753 are positioned in the reservoir region 74. The first, second and third reservoir cut-outs 751, 752, 753 are aligned with the first, second and third reservoir compartments 31, 32, 33 situated at the main body 5. The first, second and third reservoir cut-outs 751, 752, 753 are sized in correspondence with the openings 311, 312, 313 of the first, second and third reservoir compartment of the reservoir 3.

[0212] The throttle plate 7 further comprises a pump opening 76 for the pump 2.

[0213] In a preferred embodiment the throttle plate 7 is made out of a single unitary body of hard material, e.g. of metal or ceramic. The throttle plate 7 may have a thickness of at most 5 mm, in particular at most 3 mm, but preferably at most 1 mm. Preferably, the throttle plate 7 is made out of a metal plate. The features of the throttle plate 7, like the throttle orifices, and/or pump opening, etc., may be manufactured by cutting operations, like wa-

terjet-cutting or laser-cutting.

[0214] The connector plate 8 has a similar structure as the earlier shown function plate 6. In fact, the connector plate 8 may serve as a second function plate 6.

[0215] The connector plate 8 has a front side 8F and a back side 8B. A registration code may be provided at the front side of the connector plate 8.

[0216] The connector plate 8 here has a rectangular outer contour. The connector plate 8 is provided with rounded corners and has substantially straight edges. The connector plate 8 has a thickness of at most 5 mm, in particular at most 3 mm, but preferably at most 1 mm.

[0217] The connector plate 8 has substantially the same width and length dimensions as the function and throttle plate 6, 7. The connector plate 8 is stackable with the function and throttle plate 6, 7 to form a stack.

[0218] The connector plate 8 comprises a plurality of boltholes 87 for the bolts 14.

[0219] The connector plate 8 comprises a key receiver 53'. The key receiver 53' is configured to receive the alignment key 53 which is provided at the main body 5. The key receiver 53' is configured to align the connector plate 8 with respect to the port face 51 of the main body 5. The key receiver 53' is positioned at an edge of the connector plate 8. The key receiver 53' comprises the key recess which is sized to receive the key protuberance of the key 53. The key 53 fits inside the key recess.

[0220] The connector plate 8 comprises at least one connector hole 81. The hole 81 is a through-hole which extends from the back side to the front side of the connector plate 8. The connector hole 81 provides a through flow for a hydraulic liquid. The at least one connector hole 81 is positioned in alignment with a port 92 of an end body port face 91 of the end body 9. The at least one connector hole 81 has a diameter which is substantially equal to the diameter of the port 92.

[0221] The connector plate 8 is a laminated plate. The laminated plate 8 here comprises three main layers.

[0222] At the front side, the connector plate 8 comprises a front layer 80F. The front layer is provided with connector holes 81 which are each aligned with the ports 92 of the end body port face 91.

[0223] At the back side, the laminated connector plate 8 comprises a back layer 80B. The back layer is provided with the holes 81 and optionally at least one slotted passageways 80.

[0224] In between the front and back layer 80F, 80B, the connector plate 8 comprises an intermediate layer 80I. The front and back layer 80F, 80B preferably comprise a plastic material, for example the layers can be moulded onto the intermediate layer 80I.

[0225] Here, the intermediate layer 801 comprises a filter element, in particular a filter membrane 88. Preferably, the filter membrane comprises a woven material. In particular, the intermediate layer 801 comprises a support sub-layer 89 for supporting the filter membrane.

[0226] The slotted passageway 80 is provided by a groove which is provided in a layer, here the back layer

80B, of the connector plate 8. The groove 80 here extends in between at least two holes 81 of the connector plate. The back layer 80B comprises through holes at the position of the holes 81 of the connector plate 8. The groove in between the through holes of the back layer 80B has a groove depth which is smaller than the thickness of the laminated connector plate 8, in particular at most equal to the thickness of the back layer 80B to obtain a filter function by the filter membrane 88 of the intermediate layer 801.

[0227] In manufacturing the connector plate 8, the back layer 80B may include an open passageway which is open from the back to the front side front layer 80B, which allows a manufacturing of the back layer 80F by cutting, or stamping, which may be cost effective in a mass production.

[0228] Preferably, the groove in the back layer 80B which forms the passageway 80 has a groove end which is formed by a through hole. The groove end may have a depth which is equal to the thickness of the back layer 80B. A groove section in between the groove ends may have a reduced depth with respect to the groove ends. The depth of the groove section which forms the passageway 80 may be smaller than a thickness of a layer, e.g. the back layer 80B, in which the back layer 80B may be manufactured by moulding before the front layer 80F is laminated to the intermediate layer 801.

[0229] The front layer 80F, the intermediate layer 801 and the back layer 80B are laminated to obtain a one piece connector plate 8. The intermediate layer 801 comprises the filter membrane 88. The filter membrane 88 substantially extends about the whole intermediate layer 801. The intermediate layer 801 further may comprise a support sub-layer for supporting the filter membrane 88. The filter membrane 88 provides filter membrane sections positioned at the holes 81 and at least one reservoir cut-out 85 if present.

[0230] In a step of an embodiment of manufacturing the connector plate, the membrane 88 is connected to the support sub-layer and then laminated to the front and back layer 80F, 80B. Locally, at a position of a hole 81 of the connector plate 8, the front and back layer 80 F, 80B are both locally open from a back side to a front side wherein the support sub-layer of the intermediate layer 801 is also locally open which provides a filter membrane in the hole 81.

[0231] The connector plate 8 comprises at least one slotted passageway 80, here at the backside of the connector plate 8.

[0232] The connector plate 8 is provided with one or more seals 82 at the front and back side 8F, 8B of the connector plate. The seals 82 are arranged to seal the connector plate 8 with respect to an abutting component which is here - as shown in Fig.1- the end body 9 and the throttle plate 7. Another order of the plates is possible.

[0233] The seal 82 is preferably permanently affixed to the connector plate 8. The seal may be fixed by an in-mould operation. In particular, the seal 82 comprises a

silicone or rubber material.

[0234] The seal 82 is recessed in the plate 8 which provides a flexibility to the seal 82 to let the seal 82 to be compressed when the connector plate 8 is sandwiched in between the end and main body 9,5. The seal 82 in recessed form may delimit a side wall or portion of a side wall of the respective passageway 80 or hole 81.

[0235] The seal 82 comprises a plurality of seal ribs 821,822. The seal ribs are positioned at a port region 810 of the connector plate 8 which port region 810 includes a plurality of holes 811,812 and slotted passageways 801, 802. The holes and passageways of the connector plate 8 are provided to define flow paths of the hydraulic circuit which is embedded in the hydraulic pump unit. After connecting the connector plate 8 to the end body 5, the layout of the slotted passageway 801, 802 determines a particular liquid connection in between ports 92 in the port face 91 of the end body 9. This liquid connection in between the respective ports forms a particular flow path which determines the hydraulic circuit of the pump unit 1.

[0236] The depicted connector plate 8 comprises the port region 810 and a reservoir region 84. The port region 810 of the connector plate 8 is positioned at a top region and comprises the at least one connector hole 81. The at least one connector hole 81 is positioned in the port region 810. The reservoir region 84 is positioned below the port region 810. The reservoir region 84 is delimited from the port region 810 by a seal rib 823. The reservoir region 84 is delimited from the port region 810 at both sides of the connector plate 8 by a seal rib 823. The seal rib 823 encircles the reservoir region 84. The reservoir region 84 of the connector plate 8 corresponds with the respective reservoir regions 64,74 of the function and throttle plate 6,7.

[0237] The connector plate 8 here comprises a first, second and third reservoir cut-out 851, 852, 853. The reservoir cut-out provides an open through flow from the back side to the front side of the connector plate 6. The first, second and third reservoir cut-out 851,852, 853 are positioned in the reservoir region 84. The first, second and third reservoir cut-outs 851,852, 853 are aligned with the first, second and third reservoir compartments 31,32,33 situated at the main body 5. The first, second and third reservoir cut-outs are sized in correspondence with the openings 311,312,313 of the first, second and third reservoir compartment of the reservoir 3.

[0238] Here, the first, second and third reservoir cut-outs 851, 852, 853 of the connector plate 8 are each provided with a filter membrane section 88. The filter membrane 88 has a first, second and third filter membrane section 881,882,883 in which each section spans the reservoir cut-out. The filter membrane section is formed by the filter membrane 88 of the intermediate layer 801.

[0239] The connector plate 8 further comprises a pump opening 86 for the pump 2.

[0240] The first and third reservoir cut-outs 851, 853

comprise an air vent 861,862. The air vent 861,862 serve to discharge separated air from the reservoir cut-outs 851,853 to the pump opening 86. Preferably, the air vent 861, 862 is formed by an open passageway. The open passageway is positioned upstream and close to the filter membrane section 881, 882.

[0241] The end body 9 is designed to sandwich the one or more plates 6,7,8 together with the main body 5.

[0242] The end body 9 comprises a plurality of bolt-holes 97 for the bolts 14 or the like that mounting the end body 9 to the main body 5. Here the bolt-holes 97 are aligned with the thread holes 57 of the main body 5.

[0243] At a front side 9F, the end body 9 comprises a motor mount 98 for mounting the motor 10 to the pump unit 1 to drive the pump 2 of the pump unit 1. The pump 2 which is installed in the main body 5 and the drive shaft 11 of the motor 10 protrudes through the end body to couple the shaft to the pump 2.

[0244] At the side facing the main body the end body 9 has a pump opening 96 that is aligned with the pump openings 66, 76 and 86 of the respective function, throttle and connector plate 6, 7, 8. The pump 2 here extends through these pump openings in the plates into the pump opening of the end body.

[0245] The end body 9 comprises multiple line connectors 99 for connecting a set of hydraulic actuators to the pump unit 1. The line connectors 99 are configured to connect a line 104, e.g. provided with an insertion end fitting, to the end body 9 for conducting hydraulic liquid to the set of actuators. Here, the line connectors 99 are embodied as simple bores. As is preferred all connectors 99 are positioned on the front side 9F of the end body 9 which allows an easy connection in one direction of the pump unit 1 to a set of hydraulic actuators.

[0246] Here, the end body 9 comprises six pairs of line connectors 99 for connecting three actuator pairs, see Fig. 7.

[0247] At the back side 9B, the end body 9 comprises a planar port face 91 at an outer surface of the end body 9. The planar port face 91 comprises a plurality of ports 92. The ports 92 are formed by duct ends of an end body channel system 90 which interconnects the ports 92 to the multiple line connectors 99. In a simple embodiment the channel system comprises parallel axial ducts, each between one port 92 and one connector 99.

[0248] If desired the channel system 90 may also comprises multiple intersecting ducts to obtain a plurality of flow parts of a hydraulic circuit.

[0249] The end body 9 here comprises a port region 910 which includes the port face 91 and a reservoir region 94. The reservoir region 94 is aligned with the reservoir regions 84, 74, 64 and 54 of the other component of the pump unit 1. The port region 910 here is positioned at a top region and the reservoir region 94 is positioned below the port region 910.

[0250] As preferred the port face 91 and any reservoir region 94 of the end body 9 are arranged without seals. A sealing of the ports 92 is obtained by placing the con-

necter plate 8 against the port face 91, wherein the connector plate 8 is provided with said seals.

[0251] A first and second inter reservoir flow path 391,392 may serve for interconnecting the reservoir compartments 31, 32, 33. The inter reservoir flow path here is formed by a blind hole which is positioned at the reservoir region 94 of the end body. The blind hole is aligned with a plate portion in between neighbouring reservoir cut-outs. The blind hole has a size which is larger than a width of the plate portion, such that a bypass is provided to let a hydraulic liquid flow through the inter reservoir flow path 391, 392 from the first to the second reservoir compartment.

[0252] The motor mount 98 is positioned at a front side 9F of the end body 9. The port face 91 is positioned at a back side 9B of the end body 9.

[0253] In this example the end body 9 comprises a wing-shaped alignment member 93L, 93R at a respective left and right side 9L, 9R of the end body 9. The alignment members 93 are configured to align the end body 9 with respect to the main body 5 in the transversal direction. The pair of left and right alignment members 93 encloses an inner space in between the alignment members 93 which is arranged to receive at least one plate and the main body 5.

[0254] Fig. 26 and 27 respectively show, schematically, a first and a different second hydraulic actuating system, e.g. for operating of a convertible roof system of a convertible car, wherein the invention and aspects thereof are incorporated.

[0255] As can be seen three pairs 111, 112, 113 of independent motion actuators are provided, e.g. one or more tonneau cover actuators 111, a pair of main bow actuators 112, and a pair of rear bow actuators 113, as often found in convertible roof systems of convertible cars. Due to differences between these roof systems a hydraulic actuation system needs to be tailored to the specific roof system in order to achieve a desired operational behaviour of the roof system. As explained the invention allows for an easy adaptation of the pump unit 1 to such varying market demands.

[0256] As will be explained the pump unit 1 in figures 26 differs from the unit 1', wherein the main body 5 is the same and one or more of the plates 6,6', 7,7', 8,8'differ. In this example also the end bodies 9, 9' are different, but one may seek to have identical end bodies in different circuit pump units 1, 1'.

[0257] The pump unit 1 of the hydraulic actuating device of figure 26 comprises the main body 5, the function plate 6, the throttle plate 7, the connector plate 8 and the end body 9 as illustrated in the preceding figures.

[0258] In the schematic drawings of figures 26 and 27 the main body 5, end body 9, 9' and plates 6,7, and 8, respectively 6',7',8', are shown as separate components with their dashed lines depicting the relevant interface surfaces thereof.

[0259] The main body 5 of the pump unit 1 is the same in figures 26, 27.

[0260] Here, the main body 5 comprises the pump 2, the motor 10, the reservoir 3 and three control valves 4. The main body 5 may comprise several other components which are common for the hydraulic circuits of both hydraulic actuating systems. Such components may include at least one pressure relief valve 107 which is connected to the third reservoir compartment 33, a non-return valve, an air vent plug, a filter plug etc.

[0261] The main body 5 comprises the port face 51 which is drafted in the schematic view by a dashed line. The port face 51 comprises a plurality of ports 52.

[0262] The function plate 6 comprises the filter membrane 68 which spans across the reservoir cut-outs and the holes 61. Further, the function plate 6 comprises the slotted passageway 60. The passageway 60 is drafted by a line which extends in a horizontal direction. Through flows from the back side to the front side of the function plate 6 as provided by the holes 61 and the reservoir cut-outs 651, 652, 653 are drafted in the layout section by a line which extends in a vertical direction.

[0263] The throttle plate 7 comprises the throttle orifices 70 indicated by a throttle symbol in the throttle plate layout section. Through flows from the back side from side of the plate are drafted in the layout section by a line which extends in a vertical direction across the layout section.

[0264] The connector plate 8 has a similar design as the function plate 6 including connector holes 81 and possibly at least one slotted passageway 80.

[0265] The end body 9 is indicated in the schematic layout by an end body layout section. The end body 9 comprises a channel system 90 for interconnecting a port 92 in an end body port face 91 with a line connector 99.

[0266] The actuating system 100 further comprises the first, second, and third actuators 111, 112, 113 which are each connected to the pump unit 1 via actuator lines 104 of which end fittings connect to the line connectors 99 of the end body 9.

[0267] The skilled person will appreciate from comparison of figures 26 and 27 that selecting the proper version of each of the plates, as well as, optionally, a proper version of the end body, allows in a very simple and reliable manner to create a pump unit adapted for inclusion in a hydraulic actuating device or system having the desired fluidic circuit.

[0268] As explained, for example in convertible roof systems, practical tests of the hydraulic system may reveal that throttling effects are not as desired. In that case it will suffice to prepare or select a differently embodied throttle plate to achieve correct throttling.

[0269] If, as desired, the throttling plate only has one or more throttle orifices and one or more through holes, so no passageways that link ports, the actual fluid paths are established by the ducts in the main body in combination with both the function plate and the connector plate.

[0270] As can be seen in figure 27 the end body may comprise one or more ducts that are not purely connect-

ing ducts between one port 92 and one connector 99. Duct 910 is an example thereof. In figure 26 this duct may be present but not in use in the end body 9. In figure 27 a valve 911 is arranged in this duct, for example a pressure relief valve. This duct 910 is also visible in figure 3, where it is shown that a valve 911 can be arranged in this duct. The same applies to ducts 912, 913 in the end body 9', which may be present in end body 9 as well but not used. In figure 27 check valves are arranged in these ducts in the end body 9'.

[0271] Therefore, in figure 2, the same main body 5 is combined with another function plate 6', throttle plate 7', and connector plate 8'. It is advantageous to use the same end body, possibly equipped with one or more valves, e.g. pressure relief or check valves, in one or more ducts in the end body. If necessary another version of the end body 9' may be used.

[0272] Preferably at least one of the plate shaped components 6, 7, 8 can be specifically configured to determine a particular hydraulic circuit. A second hydraulic circuit may differ from a first hydraulic service in that at least one flow path extends in between other holes of the plates.

[0273] Figure 28 shows in a perspective view another embodiment of the hydraulic pump unit 1. The shown embodiment generally corresponds with the embodiment as shown in figures 1-27, but has some distinguishing features which will be dealt with hereafter. Figures 29 and 30 respectively show a side and top view of the hydraulic pump unit as shown in figure 28.

[0274] As described above, the hydraulic pump unit 1 comprises a motor 10, an end body 9, a main body 5, a reservoir 3 and at least one control valve 4. In between the end body 9 and the main body 5, the pump unit 1 comprises at least one function plate 6 to define a desired hydraulic circuit. A generic part of a predetermined hydraulic circuit is defined by the main body 5 and the end body 9. A specific part of the predetermined hydraulic circuit is defined by the at least one function plate 6.

[0275] Here, the end body 9 comprises two separate parts 9.1 and 9.2 which are separately mounted to the main body 5 by bolts.

[0276] The end body 9 has a first end body part 9.1 which is mounted to a port face 51 of the main body 5. A function plate 6 is sandwiched in between the first end body part 9.1 and the port face 51 of the main body 5. In comparison with the shown embodiment in figure 2, the sandwiched function plate 6 here only extends over a port region 510 of the main body 5. The function plate 6 does not cover a reservoir region 54 of the main body 5. The first end body part 9.1 comprises at least one bolthole 97 for mounting the end body part 9.1 to the main body 5.

[0277] The end body 9 has a second end body part 9.2 which is mounted to the main body 5. The second end body part 9.2 comprises at least one bolt hole 97 for mounting the end body part 9.2 to the main body 5. The second end body part 9.2 comprises a motor mount 98 for mounting the motor 10 in operational connection with

a pump 2 of the pump unit 1.

[0278] Figure 31 and 32 show a subassembly of the first end body part 9.1 together with a connector plate 8, a throttle plate 7 and a function plate 6. The first end body part 9.1 is block shaped and has a front side 9F and a back side 9B.

[0279] At the front side 9F, the first end body part 9.1 has a planar surface for connecting a plurality of actuator lines. As in the embodiment of figure 26, a plurality of line connectors 99 are provided at the front side 9F of the first end body part 9.1. The line connectors 99 are interconnected by transversal boreholes. The line connectors 99 of the first end body part 9.1 form the end body channel system 90. The end body channel system is part of a generic part of the predetermined hydraulic circuit.

[0280] At the back side 9B, the first end body part 9.1 has a planar surface which forms an end body port face 91 provided with at least one end body port 92 as shown in figure 25. The planar end body port face 91 is configured to obtain an abutting engagement with the connector plate 8.

[0281] Figure 32 shows in a back sided perspective view the subassembly including the first end body part 9.1 as shown in figure 31. A stack of plates, including a function plate 6, a throttle plate 7 and a connector plate 8 is positioned in an abutting engagement with the first end body part 9.1. The stack of plates comprises a key recess 53'. Here, the key recess 53' is only provided at the throttle plate 7.

[0282] Figure 33 shows a subassembly of the connector plate 8, the throttle plate 7 and the function plate 6 as shown in figure 31 and 32 in further detail. Here, the function plate 6 and the connector plate 8 have a similar configuration. Both plates 6, 8 are laminated plates. The plate comprises at least two layers of material including a support layer and a seal layer. Here, the laminated plate comprises an intermediate layer 601 comprising a metal plate as a support layer. Typically, the metal plate has a thickness of about 1mm. The metal plate is laminated with a front and back layer 60F, 60B. The front and back layer form a seal layer. The seal layer comprises a sealing material, like an elastomer or rubber material. Preferably, the seal layer is a vulcanised layer comprising a compressible material which is vulcanised to the intermediate layer.

[0283] Here, instead of a rectangular shape as shown in figures 14 and 20, the function plate 6 and the connector plate 8 have an organic shape. The outer contour has an organic shape. The outer contour has an irregular shape. The organic shape follows from a designed pattern of the at least one slotted passageway and/or at least one hole. The organic shape provides an advantage in that a volume of surrounding sealing material around a passageway 60, 80 or hole 61, 81 is limited. The limited volume of sealing material contributes to a liquid tight working of the seal layer. Each passageway 60, 80 or hole 61, 81 is surrounded by a predefined volume of sealing material which is due to the limited volume sufficient

compressible to prevent leakages. Preferably, each passageway or hole is circumvented with a predefined volume of sealing material which sealing material has a layer thickness of at least 0.05 mm and at most 1 mm, preferably at least 0.1mm and at most 0.5mm and has a width -in a plane of the plate- of at least 2 mm and at most 10 mm, particular at most in 5mm.

[0284] In a method of designing a specific function plate for a predetermined hydraulic circuit, a predefined volume of sealing material around a passageway or hole can be taken as a design rule to obtain a function or connector plate which is leakage proof. Herewith, a predefined layer thickness of a seal layer and a predefined width of sealing material around a passageway or hole can be taken into account in designing a particular pattern of a group of passageways and holes of the function or connector plate. An obtained pattern for the function and/or connector plate can be copied in a design to obtain a pattern of ports 52,92 in a port region of a main or end body 5,9. Such a designed function or connector plate can be manufactured by a cutting technology, like a stamping, water or laser cutting technology.

[0285] As shown in figure 33, in comparison with the function and connector plate of figures 14 and 20, the function and connector plate 6, 8 are here configured without boltholes (67, 87). Here, the function and connector plate has an outer contour including a group of U-shaped recesses which recesses are positioned to make the plate fit in between a group of bolts. The recesses further contribute to the organic irregular shape of the plate.

[0286] The function plate 6 has no key recess 53'. The function plate 6 comprises at least one slotted passageway 60. The slotted passageway 60 is a through passageway which is truly open from a front side 6F to a back side 6B of the function plate 6.

[0287] The connector plate 8 has no key recess 53'. The connector plate 6 comprises at least one slotted passageway 80. The slotted passageway 80 is an open passageway which is truly open from a front side 8F to a back side 8B of the connector plate 6.

[0288] Each of the function and connector plate can be made by a cutting technology, like stamping, water cutting or preferably laser cutting technology. Each plate has a plate thickness of at least 0.2mm and at most 2mm.

[0289] Figure 34 shows a perspective view of the throttle plate 7 as shown in figure 33. The throttle plate 7 has a single layer. Here, the throttle plate 7 consist of a metal plate. The throttle plate 7 can be manufactured by at laser cutting technology. Small holes, in particular any apertures having a diameter of about 20 μm can be manufactured by laser drilling, while large holes, in particular orifices having a diameter of about 600 μm can be manufactured by laser cutting. Advantageously, such a throttle plate 7 manufactured by laser cutting technology can be manufactured relatively quick and contributes to a logistic flexibility to manufacture a throttle plate which is specific for a particular predetermined hydraulic circuit.

To allow a manufacturing of the throttle plate by laser cutting technology, the throttle plate 7 preferably has a thickness of at least 0.2 millimetres and in particular at most 2 mm, in particular the throttle plate 7 has a thickness of 0.5 mm.

[0290] For the same reason of allowing laser cutting technology for manufacturing, it is advantageous to use a function and/or connector plate with a substantially same thickness. For example, the function and/or connector plate may comprise a metal plate of at least 0.3mm and at most 2mm, in particular the metal plate has a thickness of about 1mm, wherein the metal plate is provided at both sides with a seal layer of at least 0.05 mm and at most 1 mm, preferably of about 0.3 mm.

[0291] It is to be understood that the disclosed embodiments are merely exemplary of the invention, which can be embodied in various forms. According to the invention, numerous variants are possible in addition to the embodiment shown in the figures.

[0292] In a variant of the illustrated embodiment of the main body, the main body may comprise at least two separate parts. Instead of an incorporation of several technical functions into a main body part formed as a one piece item, the technical functions may be carried out by dedicated separate parts of the main body part. The separate parts of the main body may be configured to carry out a particular technical function, e.g. the main body may have a separate part provided with at least one valve seat for connecting a control valve. In a variant, a separate part of the main body may be provided which separate part comprises a channel system or a pump recess.

[0293] In a variant of the illustrated embodiment, the line connectors may be provided on the main body instead of on the end body.

[0294] In a variant of the illustrated embodiment, the port face of the main body and/or of the end body may comprise a slotted passageway to interconnect at least one port of the port face with another port of the port face. The slotted passageway may extend from a first port to a second port across the port face. The slotted passageway may determine a flow path which is a common flow path of several hydraulic circuits in which the pumps unit is applied.

[0295] In a variant of the illustrated embodiment of the function and connector plate, the function and connector plate may include at least one slotted passageway at both the front and the back side of the plate.

[0296] In a variant of the illustrated embodiment, the separate throttle and function plate may be integrated into a single plate in which the single plate comprises both at least one throttle orifice and at least one slotted passageway. The single plate may be a single layer plate or a laminated multilayer plate, in which several plates are fixed to each other.

[0297] In a variant of the illustrated embodiment, the seal may be arranged as a separate solid seal plate including openings which correspond with ports of the port face or holes of an abutting plate instead of separate

individual seals which are locally fixed to the function or connector plate.

[0298] The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language, not excluding other elements or steps).

[0299] Any reference signs in the claims should not be construed as limiting the scope of the claims or the invention.

[0300] The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0301] Embodiments are defined in the following clauses:

1. Hydraulic pump unit (1) adapted to supply pressurised hydraulic liquid to a set of hydraulic actuators (110) comprising:

- a pump (2);
- a reservoir (3) for hydraulic liquid;
- multiple line connectors (99) adapted to connect the set of hydraulic actuators (110) to the pump unit (1) via actuator lines (104);
- at least one valve seat (40), where an electrically operable valve (4) is or can be installed;
- a main body (5) including a channel system (50) for the hydraulic liquid, which channel system (50) comprises multiple ducts (501) which interconnect the pump (2), the reservoir (3) and the valve seat (40), in which each duct forms a flow path of a hydraulic circuit (101) and which channel system (50) includes ducts having duct ends (502) which define multiple ports (52) in a common port face (51) of the main body, **characterised in that**, the port face (51) is a planar face of an outer surface of the main body (5),

and in that the pump unit (1) further comprises:

- a function plate (6), wherein the function plate comprises at least one slotted hydraulic liquid passageway (60) which extends across the function plate (6), wherein the function plate is retained in position parallel to the port face (51) of the main body such that the slotted passageway (60) mates with at least two ports (52) of the port face (51) to define a flow path in between these ports (52);
- an end body (9) which sandwiches the function plate (6) between the port face (51) of the main body (5) and the end body (9).

2. Pump unit according to clause 1, wherein the mul-

multiple line connectors (99) are provided on the end body (9), wherein the end body (9) comprises an end body channel system (90) for the hydraulic liquid with multiple ducts, in which each duct forms a flow path of a hydraulic circuit, wherein the end body channel system includes ducts (901) having duct ends (902) which define multiple ports (92) that are situated in a common and planar end body port face (91) of an outer surface of the end body, wherein the end body channel system (90) interconnects a line connector (99) and a port (92) of the end body port face (91).

3. Pump unit (1) according to any of the preceding clauses, wherein the end body (9) comprises at least two pairs of line connectors (99) for connecting the pump unit to the set of motion independent actuators.

4. Pump unit (1) according to any of the preceding clauses, wherein the function plate (6) comprises multiple holes (61) in addition to the at least one slotted passageway (60) which multiple holes (61) and at least one slotted passageway (60) each extend from a back side to a front side through the function plate (6).

5. Pump unit (1) according to clause 4, wherein the multiple holes (61) in the function plate (6) are each arranged in alignment with one of the multiple ports (52) of the port face (51) of the main body (5).

6. Pump unit (1) according to any of the preceding clauses, wherein the function plate (6) comprises a seal rib (621) which encircles a slotted passageway (60), e.g. an synthetic plastic seal rib.

7. Pump unit (1) according to clause 4, wherein the function plate (6) comprises a seal rib which encircles a hole (61).

8. Pump unit (1) according to any of the preceding clauses, wherein the function plate (6) is a laminated plate, wherein the laminated plate comprises at least two layers including a support layer for providing rigidity to the function plate, which support layer preferably comprises a metal plate, and the at least two layers further include at least one a seal layer for a liquid tight sealing of the function plate under a compression which seal layer includes a compressible sealing material, which is preferably an elastomer material.

9. Pump unit (1) according to clause 8, wherein a predefined volume of sealing material circumvents a slotted passageway or hole of the function plate, wherein the predefined volume has a width of at least 2mm and at most 10mm, such that an applied compression in an assembly of the function plate to the main body results in a liquid tight connection.

10. Pump unit (1) according to clause 8 or 9, wherein the at least one slotted passageway is spaced at a distance of at least 2mm away from another slotted passageway or borehole.

11. Pump unit (1) according to any of the clauses 8-10, wherein the laminated plate comprises an intermediate layer (601), a front layer (60F), provided with said multiple holes (61) and/or said at least one slotted passageway (60), and a back layer (60B), provided with said multiple holes (61) and/or said at least one slotted passageway (60).

12. Pump unit (1) according to any of the preceding clauses, wherein the function plate comprises a filter material layer covering said one or more slotted passageways and/or holes in the function plate when present, e.g. in an embodiment the filter material layer is a layer of a laminated function plate, e.g. an intermediate layer between the front layer and the back layer of clause 8.

13. Pump unit (1) according to clause 6, or 7, wherein the seal rib (62) partly protrudes from a face of the function plate and is partly recessed within the function plate surface, e.g. in an embodiment of clauses 11 and 12 to adjoin the intermediate filter layer, the seal rib forming a sidewall of the respective passageway (60) or hole (61).

14. Pump unit (1) according to any of the preceding clauses, wherein the pump unit further comprises a throttle plate (7), distinct from the function plate (6), wherein the throttle plate (7) is retained in position parallel with the port face (51) of the main body (5) and with the function plate (6) in a sandwich between the main body and the end body, wherein the throttle plate (7) comprises at least one hydraulic liquid throttle orifice (70) which is sized to provide a throttling of passing hydraulic liquid, which throttle orifice (70) extends from a back side (7B) to a front side (7F) of the throttle plate (7).

15. Pump unit (1) according to clause 14, wherein a single throttle orifice (70) comprises a group of apertures (73) that throttle the hydraulic liquid and also filter passing hydraulic liquid.

16. Pump unit (1) according to clause 2, wherein the pump unit further comprises a connector plate (8), distinct from the function plate (6) and from the throttle plate if present, wherein the connector plate is retained in position in parallel with the port face of the end body (9), wherein the connector plate (8) comprises at least one hydraulic liquid hole (81) that extends from a back side to a front side through the connector plate in alignment with one of the multiple ports (92) of the port face (91) of the end body (9).

17. Pump unit according to clause 16, wherein connector plate further comprises at least one slotted hydraulic liquid passageway which extends across the connector plate (8), such that the slotted hydraulic liquid passageway mates with at least two ports (92) of the port face (91) of the end body (9) to define a flow path in between these ports (92).

18. Pump unit according to clause 16 or 17, wherein the connector plate (8) is provided with a seal rib (621) which encircles a hole (81) therein or a slotted hydraulic liquid passageway, e.g. said seal rib sealing against the end body.

19. Pump unit according to any of the preceding clauses, wherein a stack of at least one function plate (6) is sandwiched between the port face (51) of the main body and the port face (91) of the end body, wherein the stack of plates is a multi-layer one piece item provided by producing a fixed connection of several pre-fabricated plates, e.g. by fixating a stack of prefabricated plates in which each plate is manufactured by a laser cutting technology.

20. Pump unit according to at least clauses 1, 2, 14, and 16, wherein a stack of at least one function plate (6), throttle plate (7), and connector plate (8) is sandwiched between the port face (51) of the main body and the port face (91) of the end body, preferably with the throttle plate between the function plate (6) and the connector plate (8).

21. Pump unit according to clause 20, wherein the throttle plate (7) is arranged between the function plate (6) and the connector plate (9), and wherein the function plate and the connector plate are, at the respective side thereof adjoining the throttle plate, provided with one or more sealing ribs each encircling any slotted hydraulic liquid passageway or hydraulic liquid hole in said function plate and connector plate, wherein said sealing ribs are sealing compressed against the throttle plate.

22. Pump unit (1) according to any of the preceding clauses, wherein the reservoir (3) extends at least partly within the main body (5), and wherein the reservoir (3) has at least one reservoir opening (351) in an outer planar surface of the main body (5) that is continuous with the port face (51) of the main body, wherein the function plate (6) is arranged adjoining said port face (51) and said continuous outer planar surface, and wherein the function plate (6) comprises a port region (610) and a reservoir region (64), wherein the port region (610) includes the at least one slotted passageway (60) and is retained in position parallel to the port face (51), and wherein the reservoir region (64) includes at least one reservoir cut-out (651) in alignment with the at least one res-

ervoir opening (351) in the main body (5).

23. Pump unit (1) according to clause 22, wherein the at least one reservoir cut-out (651) comprises a filter element, in particular a filter material layer (68), which spans the reservoir cut-out (651), e.g. wherein the filter material layer is a layer of a laminated function plate, e.g. an intermediate layer between the front layer and the back layer of clause 8.

24. Pump unit according to clauses 22 and 23, wherein the reservoir comprises at least two reservoir compartments (31,32,33) that each extend at least partly within the main body and each have a respective reservoir opening in the outer planar surface of the main body, and wherein the function plate (6) has a respective reservoir cut-out for each reservoir opening, and wherein reservoir compartments are arranged hydraulically in series such that hydraulic passing out of the reservoir opening of one compartment flow through the respective filter element and return through another filter element aligned with the other compartment, e.g. the hydraulic liquid passing from said one reservoir compartment to a passageway provided in the end body via aligned cut-outs in any throttle plate or connector plate and then back through other aligned cut-outs in any throttle plate or connector plate to said other reservoir compartment.

25. Pump unit (1) according to any of clauses 22 - 24, wherein the reservoir region (64) is encircled by a seal rib (623) on the function plate (6) which separates the reservoir region (64) from the port region (610).

26. Pump unit (1) according to any of the preceding clauses, wherein the main body (5) comprises a pump recess (56) wherein the pump (2) is housed, which recess has a pump insertion opening in an outer planar surface of the main body (5) that is continuous with the port face (51) of the main body, and wherein the pump partly protrudes from said outer planar surface, and wherein the function plate (6), e.g. the reservoir region thereof, further comprises a pump opening (66) which is in alignment with the pump recess (56) so that the protruding portion of the pump is within said pump opening.

27. Pump unit (1) according to any of the preceding clauses, e.g. clause 2, wherein the end body comprises a motor mount portion (98) that is adapted to mount a pump motor (10) of the pump unit thereon or on which a motor (10) is mounted, e.g. an electric motor with rotary drive shaft (11), and wherein the main body houses the pump, e.g. a radial plunger pump, that is to be driven by said pump motor.

28. Hydraulic actuating device (100) comprising a set of hydraulic actuators (110), actuator lines (104), and a pump unit (1) according to any of the preceding clauses.

29. Method of producing a actuating device comprising a step of:

- producing a first actuating device defining a first hydraulic circuit which has a generic and specific hydraulic circuit part;
- producing a second actuating device defining a second hydraulic circuit which has a generic and specific hydraulic circuit part, characterised in that the specific hydraulic circuit part of each actuating device is defined by a function plate (6), wherein the function plate comprises at least one slotted hydraulic liquid passageway (60) which extends across the function plate (6).

30. Method in particular according to clause 29 of assembling a hydraulic pump unit (1) according to any of the clauses 1 - 27 having a hydraulic circuit of predetermined configuration to operate a set of hydraulic actuators, which the method comprises the steps of:

- providing a set of multiple function plates (6) having different arrangements of the at least one slotted hydraulic liquid passageway (60) and/or hydraulic liquid holes therein,
- selecting from said set a function plate (6) which is configured to provide a predetermined flow path of the hydraulic circuit;
- aligning the function plate with the port face (51) of the main body (5) of the hydraulic pump unit;
- sandwiching at least the function plate (6) in between the end body (9) and the main body (5).

31. Method according to clause 29 or 30, wherein the method further comprises the steps of:

- providing a set of multiple throttle plates (7) having different arrangements of the one or more throttle orifices therein,
- selecting from said set a throttle plate (7) which is configured to provide a predetermined throttling in a flow path of the hydraulic circuit;
- sandwiching at least the throttle plate (7) and the function plate (6) in between the end body (9) and the main body (5).

32. Method according to any of the clauses 29 - 31, wherein the method further comprises the steps of:

- providing an end body according to clause 2,
- providing a set of multiple connector plates (9) having different arrangements of the at least one

hydraulic liquid hole therein and/or slotted hydraulic liquid passageway (60),

- selecting a connector plate which is configured to provide a predetermined flow path to a line connector of said the end body;
- sandwiching at least the function plate (6) and the connector plate, in between the end body (9) and the main body (5).

Claims

1. Hydraulic pump unit (1) adapted to supply pressurised hydraulic liquid to a set of hydraulic actuators (110) comprising:

- a pump (2);
- a reservoir (3) for hydraulic liquid;
- multiple line connectors (99) adapted to connect the set of hydraulic actuators (110) to the pump unit (1) via actuator lines (104);
- at least one valve seat (40), where an electrically operable valve (4) is or can be installed;
- a main body (5) including a channel system (50) for the hydraulic liquid, which channel system (50) comprises multiple ducts (501) which interconnect the pump (2), the reservoir (3) and the valve seat (40), in which each duct forms a flow path of a hydraulic circuit (101) and which channel system (50) includes ducts having duct ends (502) which define multiple ports (52) in a common port face (51) of the main body, **characterised in that**, the port face (51) is a planar face of an outer surface of the main body (5),

and in that the pump unit (1) further comprises:

- a throttle plate (7) which is retained in position parallel with the port face (51) of the main body (5), wherein the throttle plate (7) comprises at least one hydraulic liquid throttle orifice (70) which is sized to provide a throttling of passing hydraulic liquid, which throttle orifice (70) extends from a back side (7B) to a front side (7F) of the throttle plate (7) which throttle plate is specific for a particular predetermined hydraulic circuit; and
- an end body (9) which sandwiches the throttle plate (7) between the port face (51) of the main body (5) and the end body (9) whereby the main body (5) and the end body (9) define a generic part of the hydraulic circuit.

2. Pump unit (1) according to claim 1, wherein the throttle plate (7) is a laminated plate, wherein the laminated plate comprises at least two layers including a support layer for providing rigidity to the throttle plate, which support layer preferably comprises a

metal plate, and the at least two layers further include at least one a seal layer for a liquid tight sealing of the throttle plate under a compression which seal layer includes a compressible sealing material, which is preferably an elastomer material.

3. Pump unit (1) according to claim 2, wherein a pre-defined volume of sealing material circumvents a throttle orifice of the throttle plate, wherein the pre-defined volume has a width of at least 2mm and at most 10mm, such that an applied compression in an assembly of the throttle plate to the main body results in a liquid tight connection. 10
4. Pump unit (1) according to claim 2 or 3, wherein the at least one throttle orifice is spaced at a distance of at least 2mm away from another throttle orifice. 15
5. Pump unit, wherein a single throttle orifice (70) comprises a group of apertures (73) that throttle the hydraulic liquid and also filter passing hydraulic liquid, wherein in particular the group of apertures (73) comprises at least five apertures (73), wherein in particular the filter apertures (73) each have a diameter of at most 100µm. 20 25
6. Pump unit (1) according to any of the preceding claims, wherein the throttle plate (7) comprises at least one bolthole (77), a key receiver (53') and/or at least one seal rib around each individual throttle orifice (70). 30
7. Pump unit (1) according to any of the preceding claims, wherein the multiple line connectors (99) are provided on the end body (9), wherein the end body (9) comprises an end body channel system (90) for the hydraulic liquid with multiple ducts, in which each duct forms a flow path of a hydraulic circuit, wherein the end body channel system includes ducts (901) having duct ends (902) which define multiple ports (92) that are situated in a common and planar end body port face (91) of an outer surface of the end body, wherein the end body channel system (90) interconnects a line connector (99) and a port (92) of the end body port face (91), wherein in particular the end body (9) comprises at least two pairs of line connectors (99) for connecting the pump unit to the set of motion independent actuators, wherein in particular the end body comprises a motor mount portion (98) that is adapted to mount a pump motor (10) of the pump unit thereon or on which a motor (10) is mounted, e.g. an electric motor with rotary drive shaft (11), and wherein the main body houses the pump, e.g. a radial plunger pump, that is to be driven by said pump motor. 35 40 45 50 55
8. Pump unit (1) according to any of the preceding claims, the pump unit (1) further comprises:

- a function plate (6) which defines a specific part of the hydraulic circuit (101), wherein the function plate comprises at least one slotted hydraulic liquid passageway (60) which extends across the function plate (6), wherein the function plate is retained in position parallel to the port face (51) of the main body such that the slotted passageway (60) mates with at least two ports (52) of the port face (51) to define a flow path in between these ports (52), wherein the function plate (6) in particular comprises multiple holes (61) in addition to the at least one slotted passageway (60) which multiple holes (61) and at least one slotted passageway (60) each extend from a back side to a front side through the function plate (6).

9. Pump unit according to any of the preceding claims, wherein a stack of at least one throttle plate (7) is sandwiched between the port face (51) of the main body and the port face (91) of the end body, wherein the stack of plates is a multi-layer one piece item provided by producing a fixed connection of several pre-fabricated plates, e.g. by fixating a stack of pre-fabricated plates in which each plate is manufactured by a laser cutting technology.
10. Pump unit (1) according to any of the preceding claims, wherein the reservoir (3) extends at least partly within the main body (5), and wherein the reservoir (3) has at least one reservoir opening (351) in an outer planar surface of the main body (5) that is continuous with the port face (51) of the main body, wherein the throttle plate (7) is arranged adjoining said port face (51) and said continuous outer planar surface, and wherein the throttle plate (7) comprises a port region (710) and a reservoir region (74), wherein the at least one throttle orifice is positioned in the port region (710) and wherein the throttle plate (7) is retained in position parallel to the port face (51), and wherein the reservoir region (74) includes at least one reservoir cut-out (751) in alignment with the at least one reservoir opening (351) in the main body (5).
11. Pump unit (1) according to claim 10, wherein the at least one reservoir cut-out (751) comprises a filter element, in particular a filter material layer (78), which spans the reservoir cut-out (751), wherein in particular the reservoir comprises at least two reservoir compartments (31,32,33) that each extend at least partly within the main body and each have a respective reservoir opening in the outer planar surface of the main body, and wherein the function plate (6) has a respective reservoir cut-out for each reservoir opening, and wherein reservoir compartments are arranged hydraulically in series such that hydraulic passing out of the reservoir opening of one com-

partment flow through the respective filter element and return through another filter element aligned with the other compartment, e.g. the hydraulic liquid passing from said one reservoir compartment to a passageway provided in the end body via aligned cut-outs in any throttle plate or connector plate and then back through other aligned cut-outs in any throttle plate or connector plate to said other reservoir compartment.

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12. Pump unit (1) according to any of the preceding claims, wherein the main body (5) comprises a pump recess (56) for housing the pump (2), which recess has a pump insertion opening in an outer planar surface of the main body (5) that is continuous with the port face (51) of the main body, and wherein the pump partly protrudes from said outer planar surface, and wherein the throttle plate (7), e.g. the reservoir region thereof, further comprises a pump opening (76) which is in alignment with the pump recess (56) so that the protruding portion of the pump is within said pump opening.
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13. Hydraulic actuating device (100), in particular a convertible roof actuating device for operating a convertible roof system, comprising a set of hydraulic actuators (110), actuator lines (104), and a pump unit (1) according to any of the preceding claims.
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14. Method of producing an actuating device comprising a step of:
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- producing a first actuating device defining a first hydraulic circuit which has a generic and specific hydraulic circuit part;
 - producing a second actuating device defining a second hydraulic circuit which has a generic and specific hydraulic circuit part, **characterised in that** the specific hydraulic circuit part of each actuating device is defined by a throttle plate (7).
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15. Method according to claim 14, wherein the method further comprises the steps of:
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- providing a set of multiple throttle plates (7) having different arrangements of the one or more throttle orifices therein,
 - selecting from said set a throttle plate (7) which is configured to provide a predetermined throttling in a flow path of the hydraulic circuit;
 - sandwiching at least the throttle plate (7) in between the end body (9) and the main body (5).
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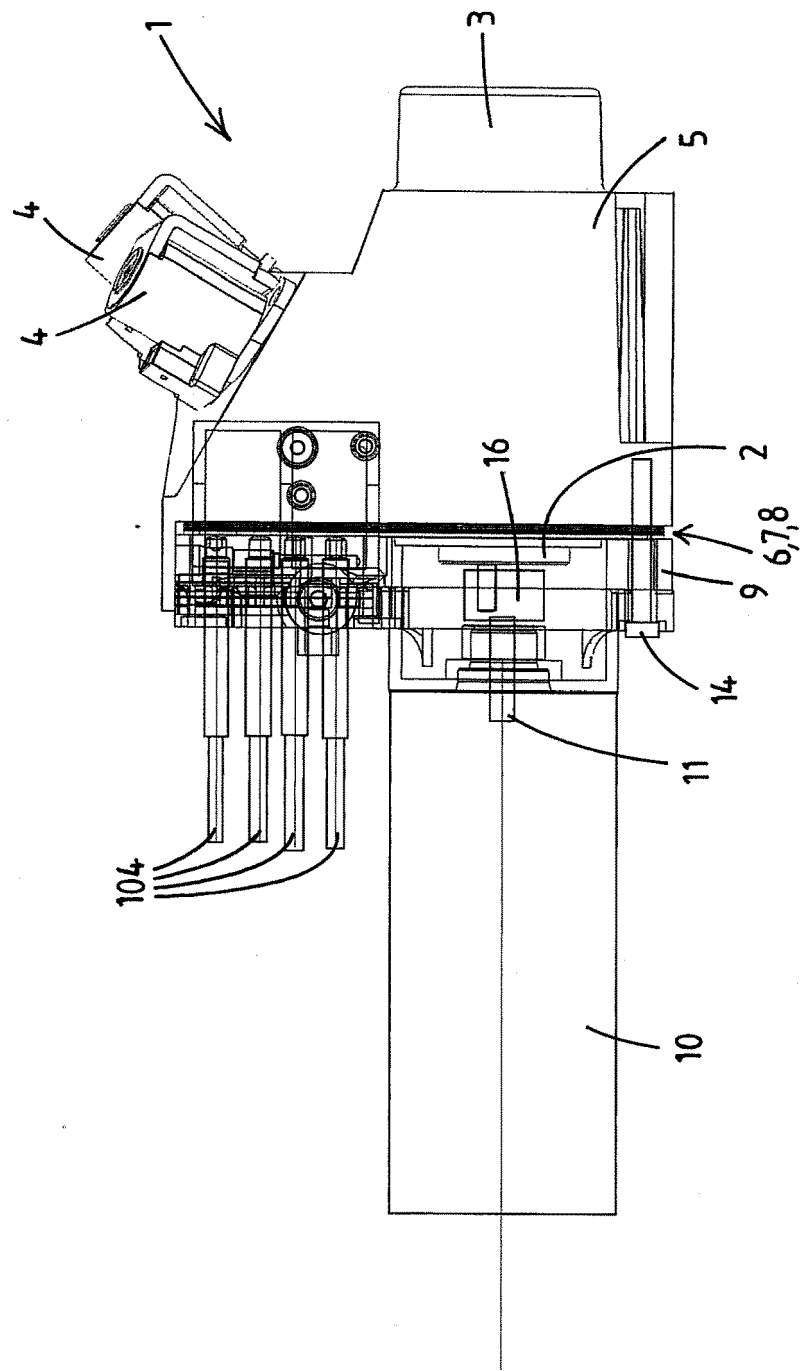


Fig.1

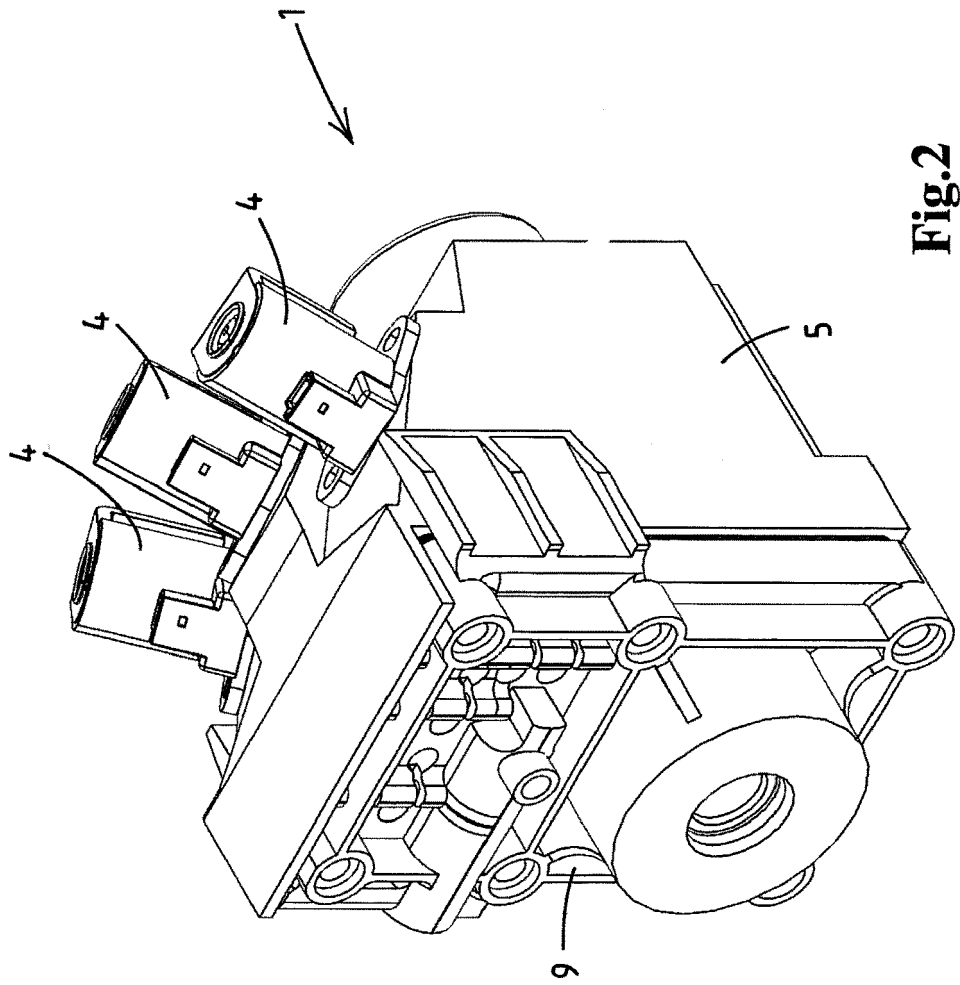


Fig.2

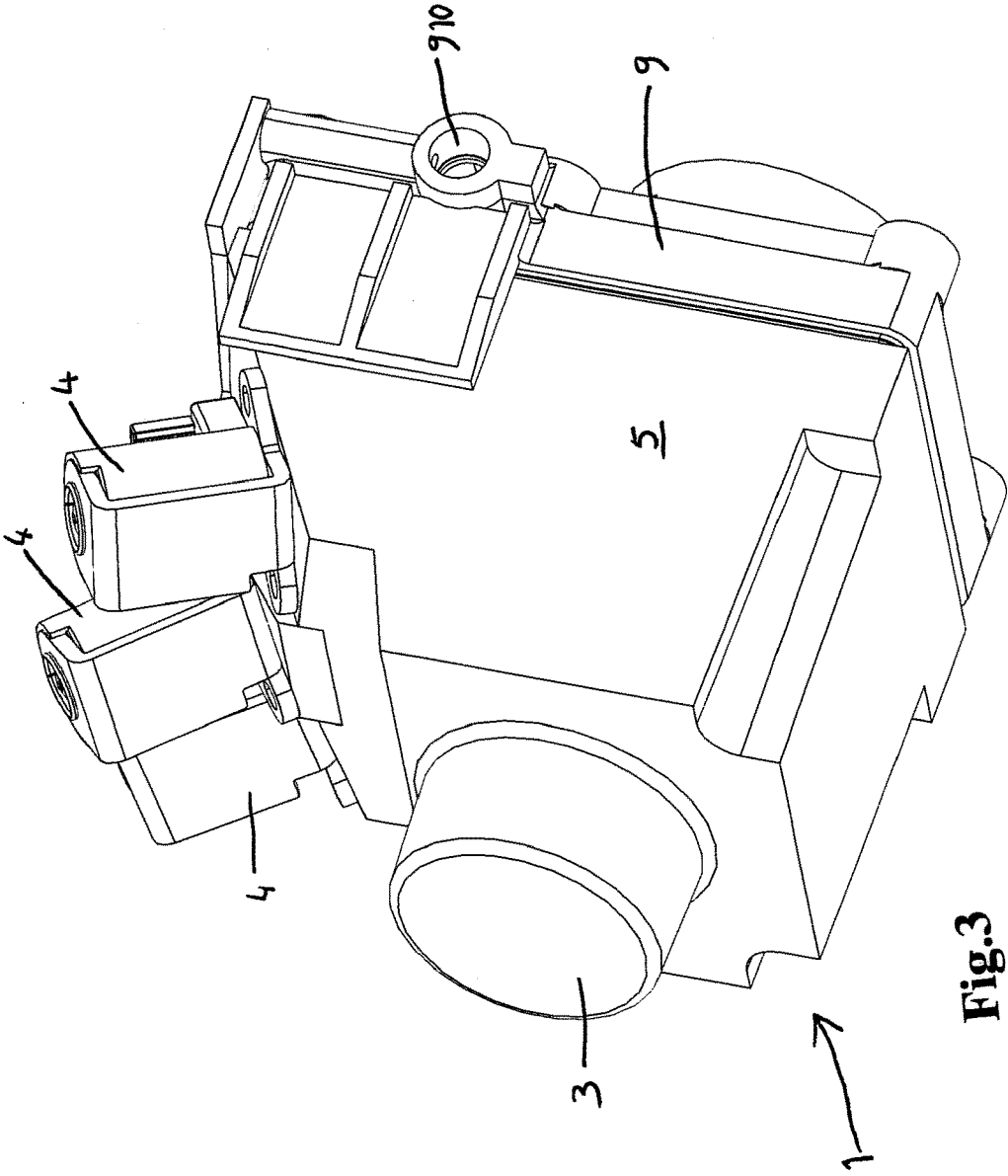


Fig.3

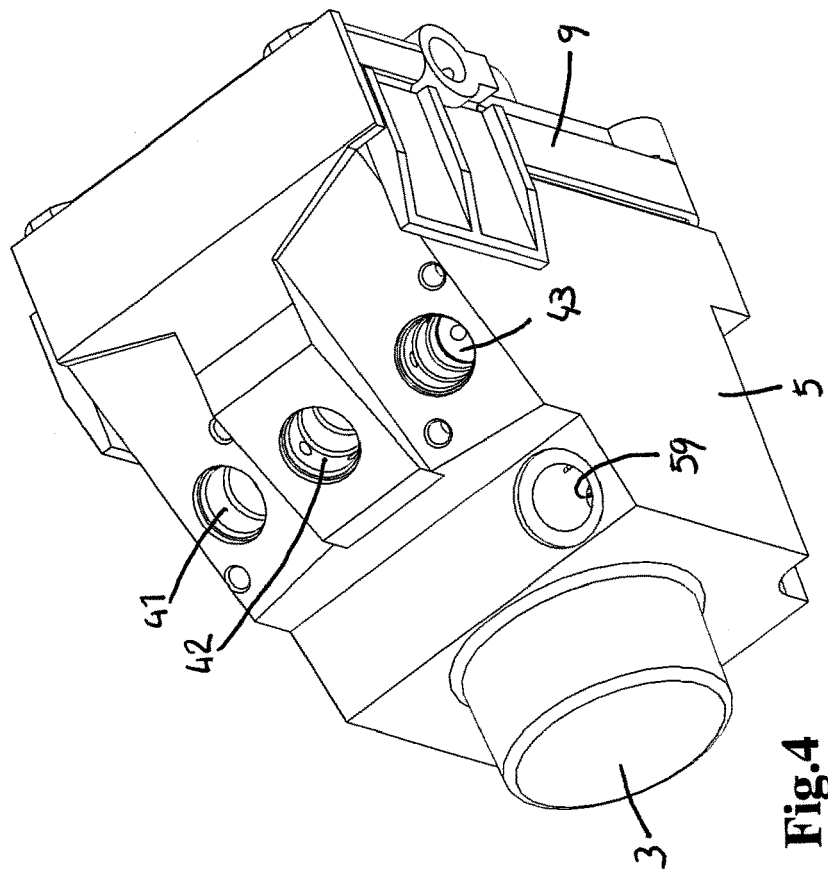
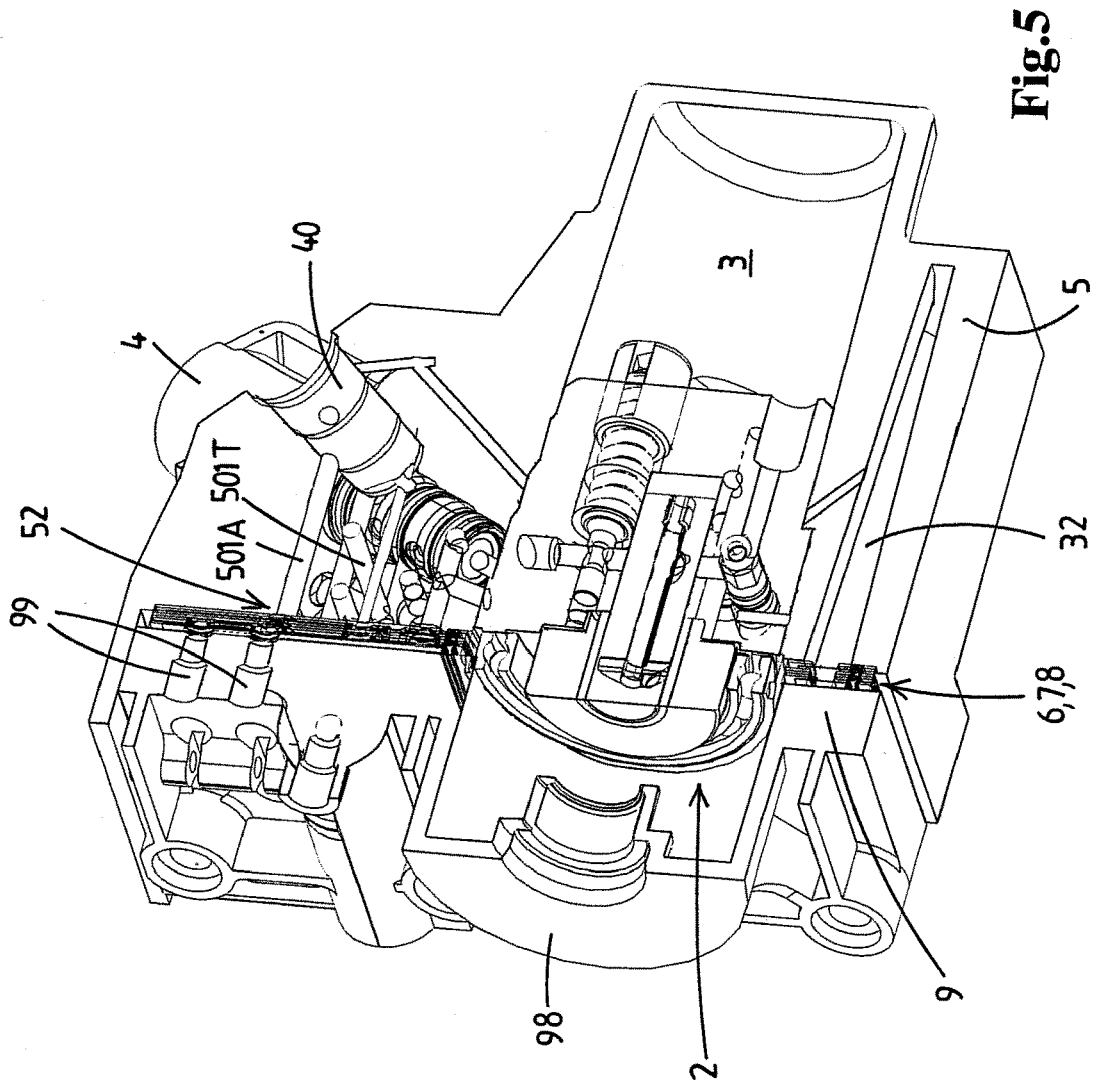


Fig. 4



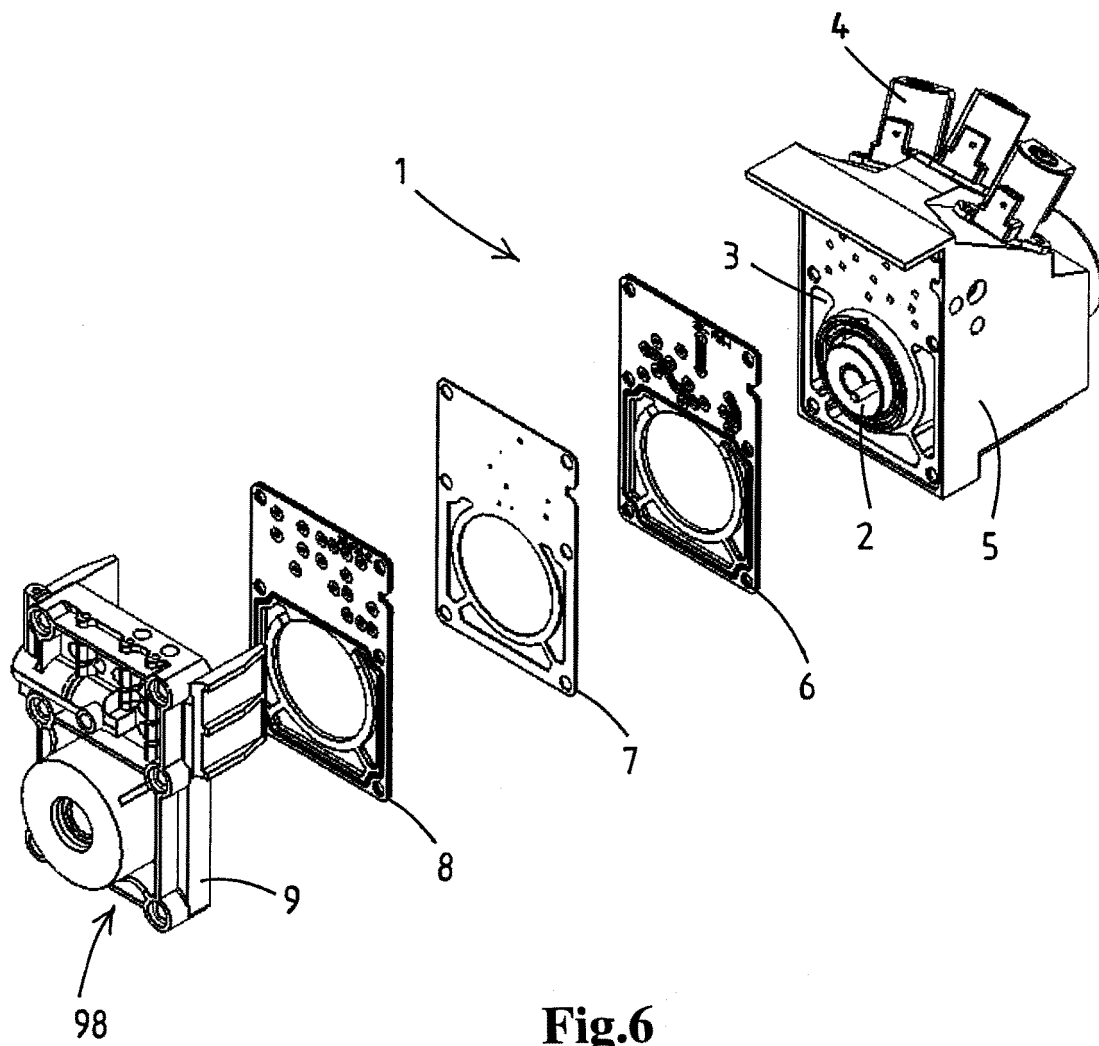


Fig.6

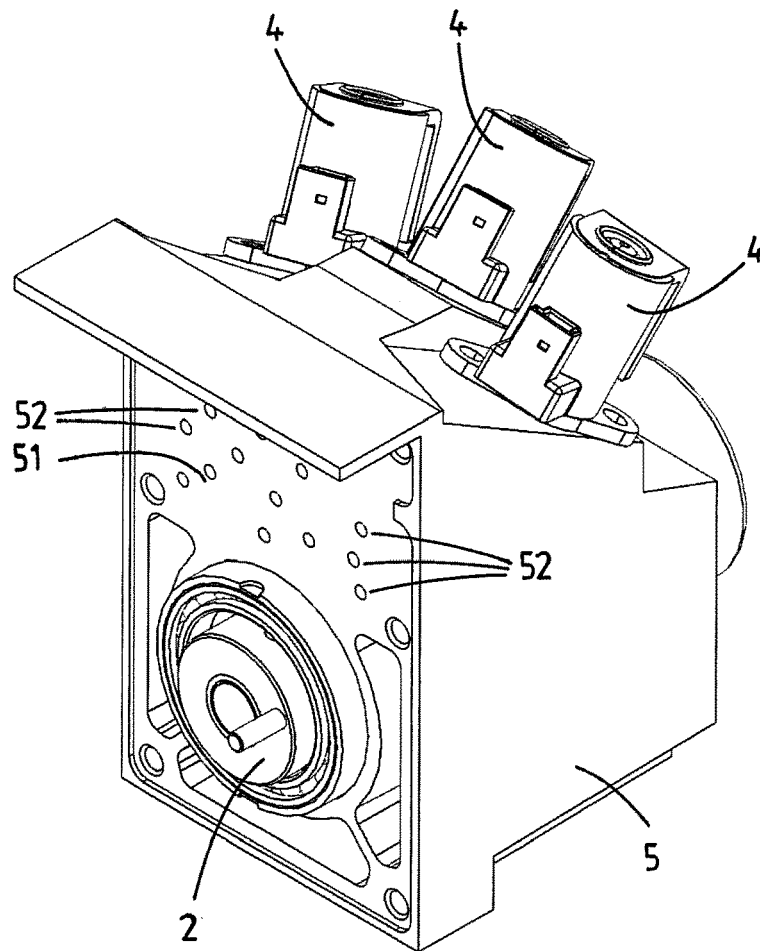


Fig.7

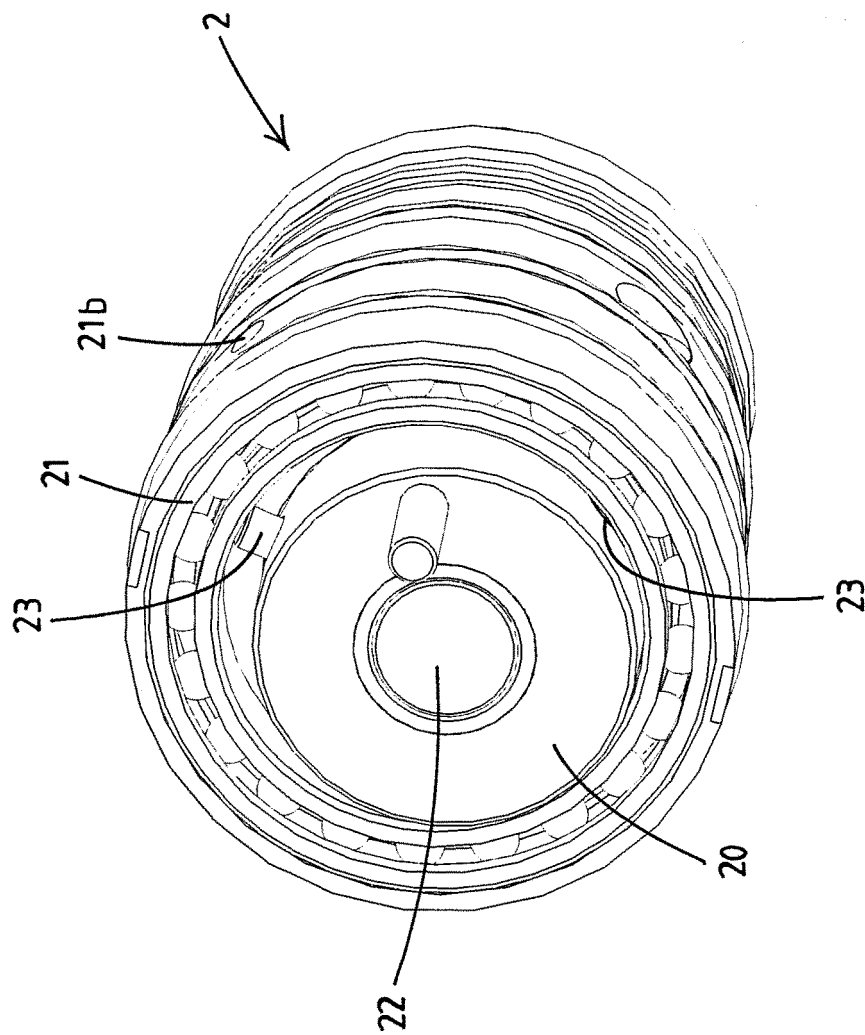


Fig.8

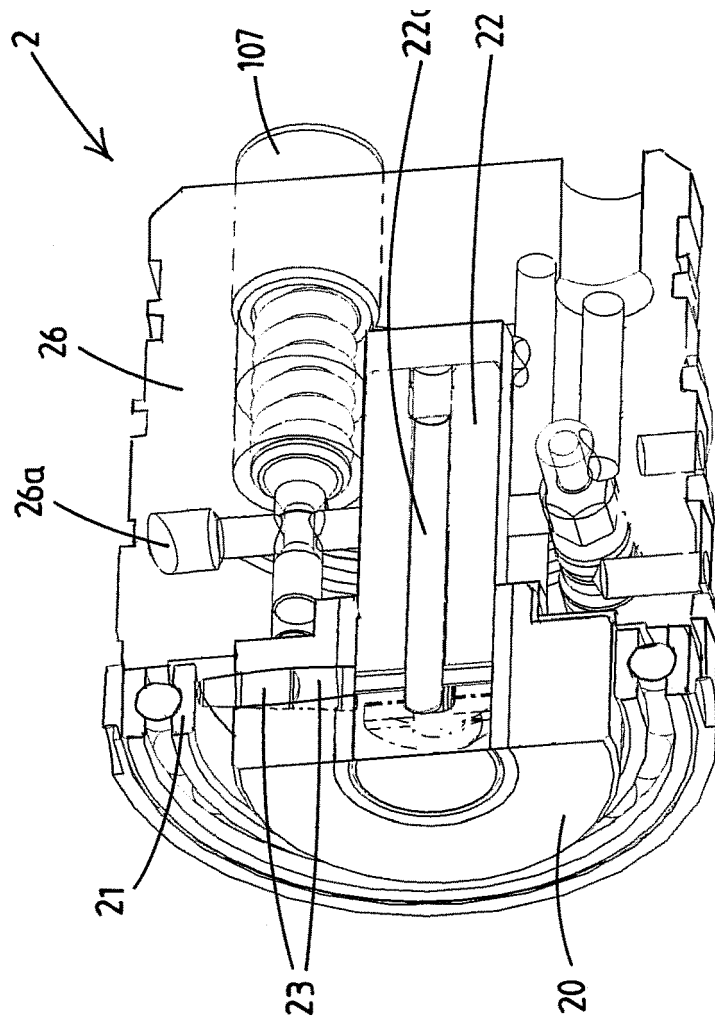


Fig.9

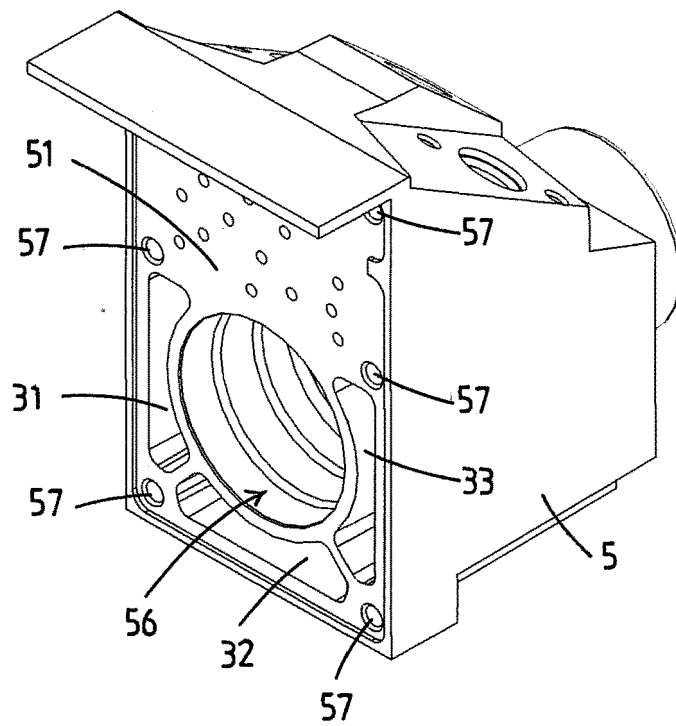


Fig.10

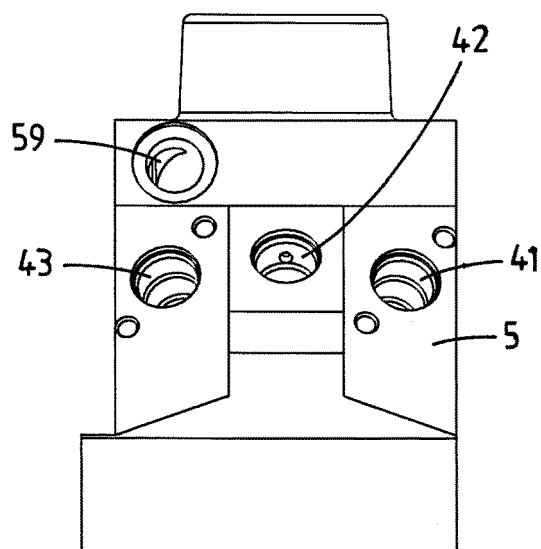


Fig.11

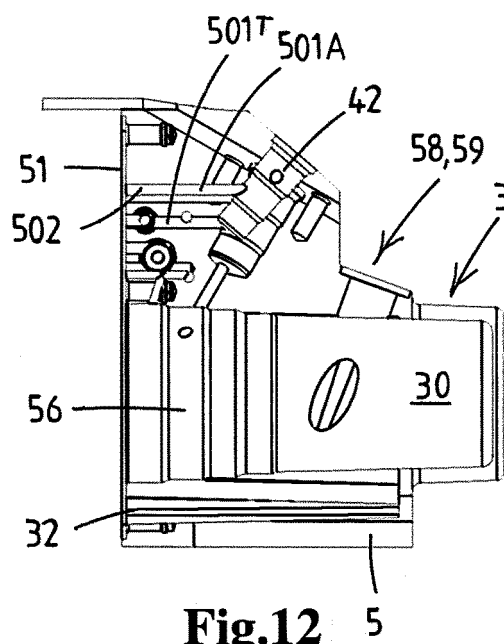


Fig.12

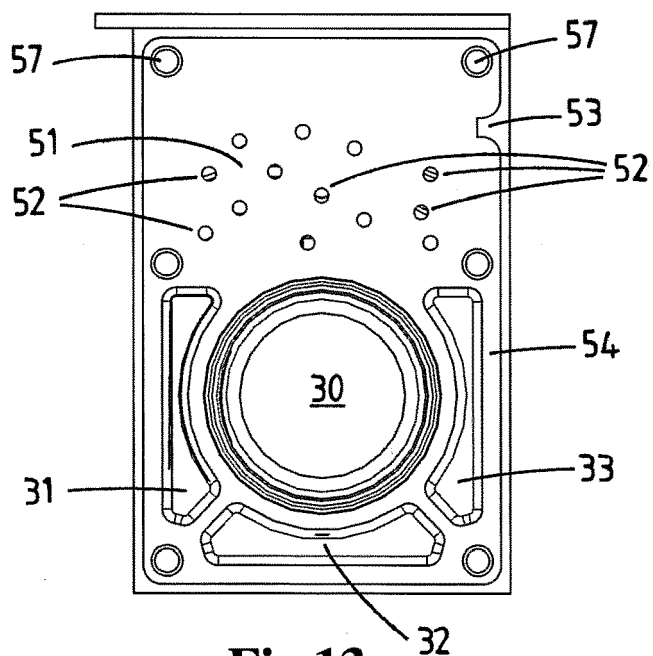


Fig.13

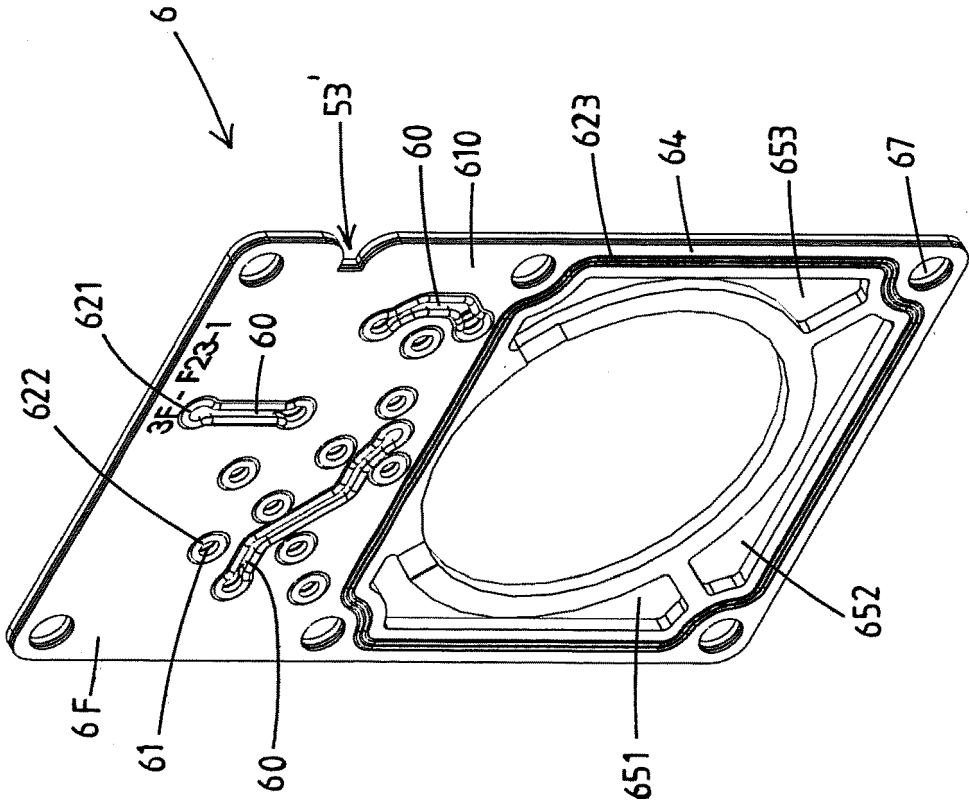


Fig.14

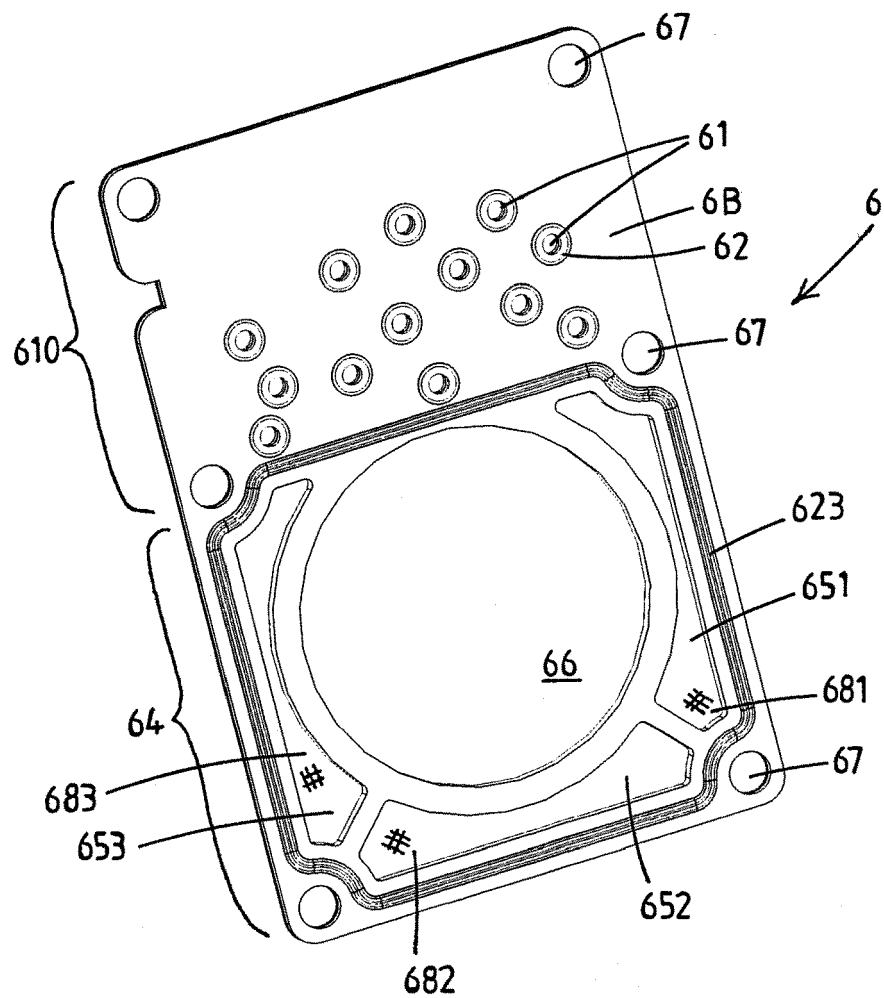


Fig.15

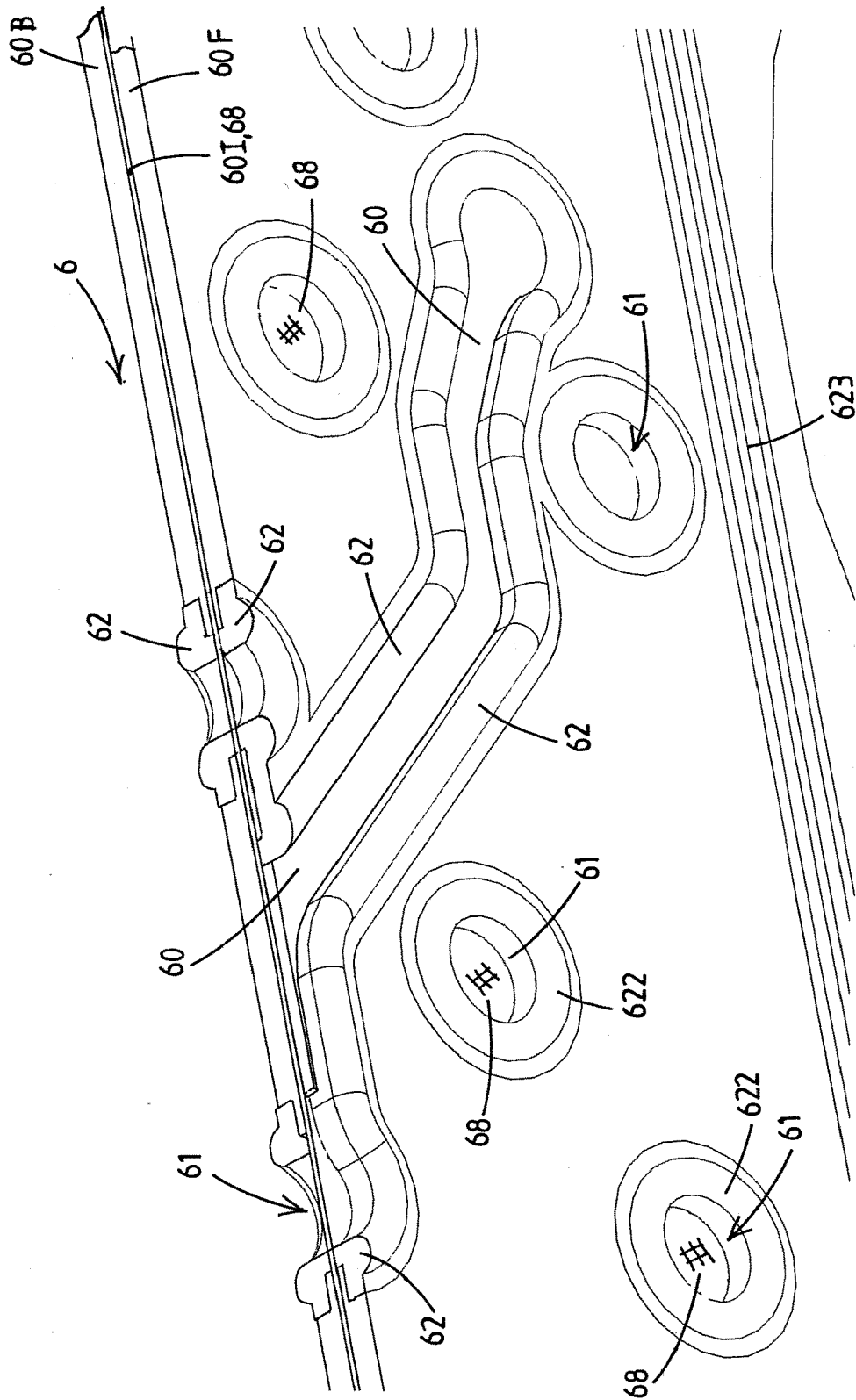


Fig.16

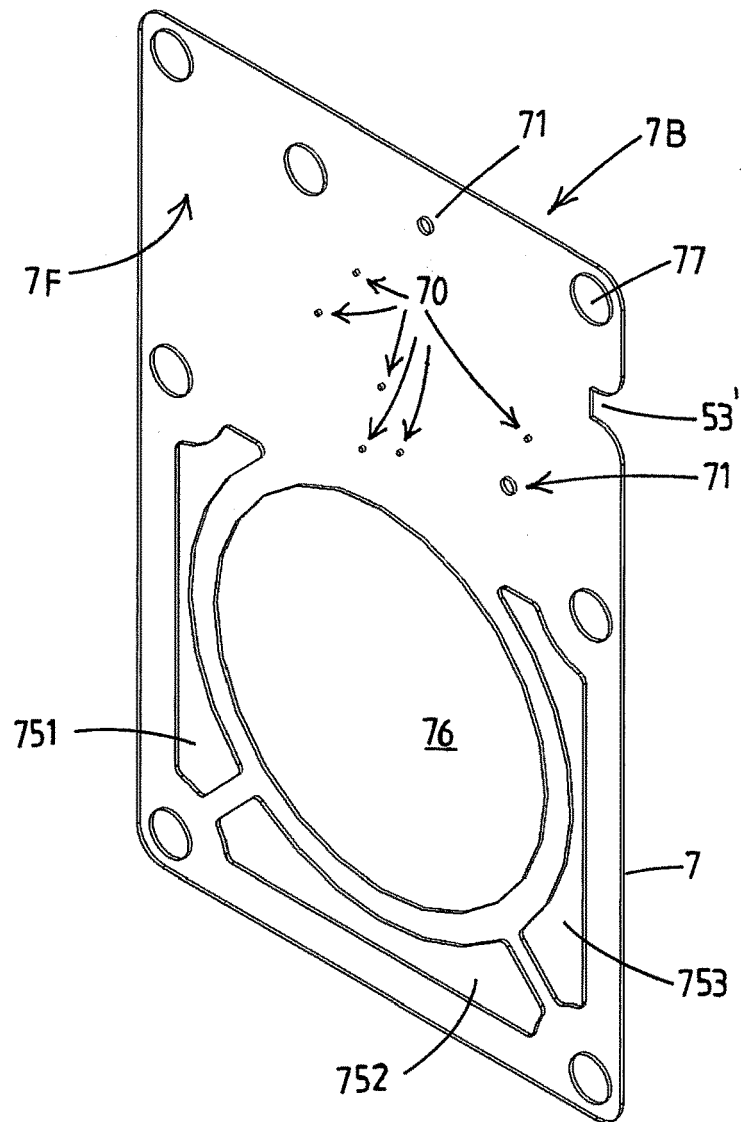


Fig.17



Fig.18

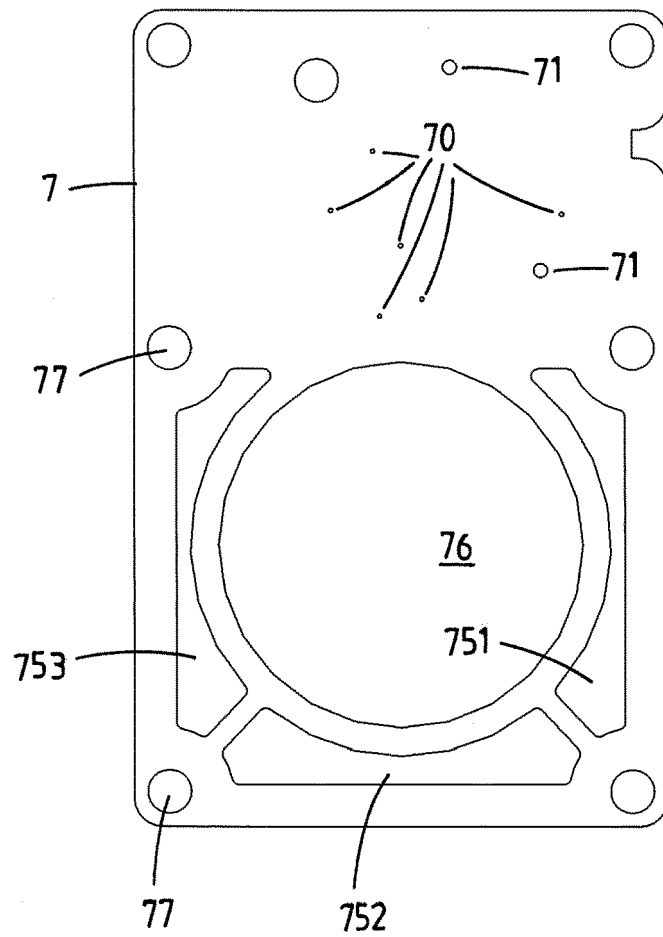


Fig.19

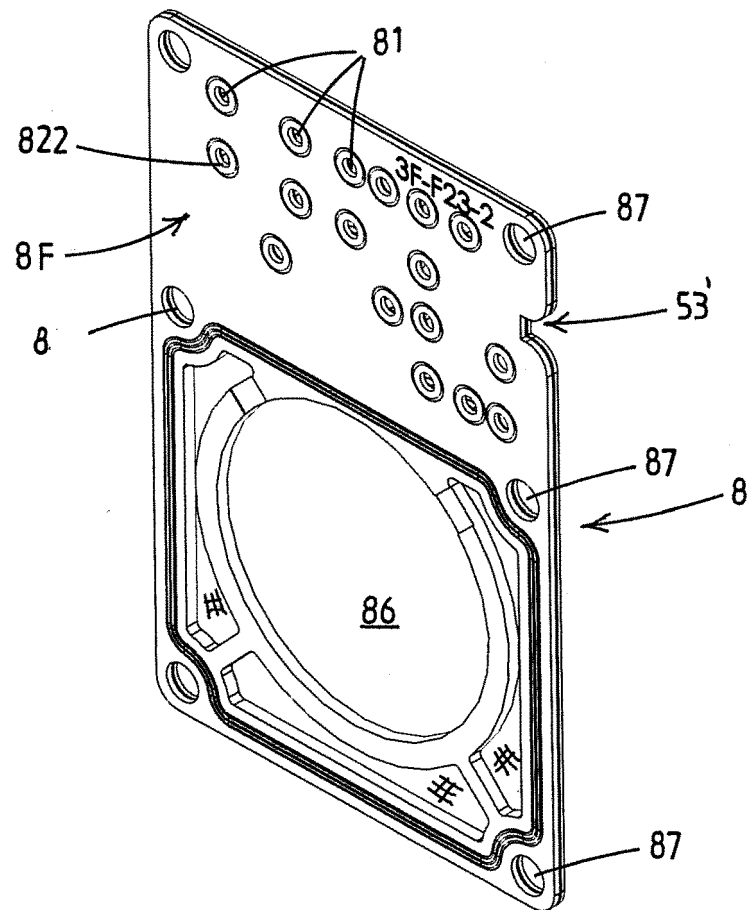


Fig.20

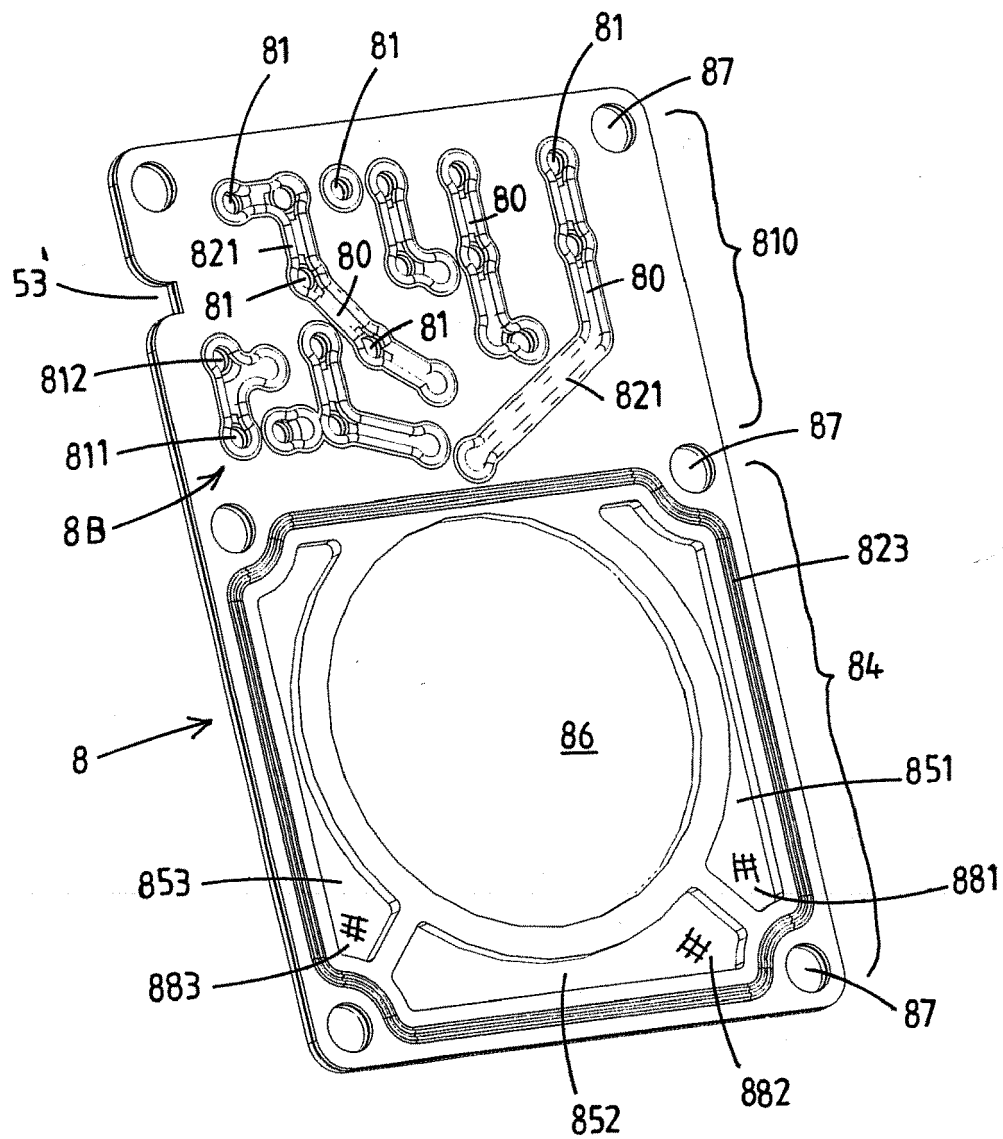


Fig.21

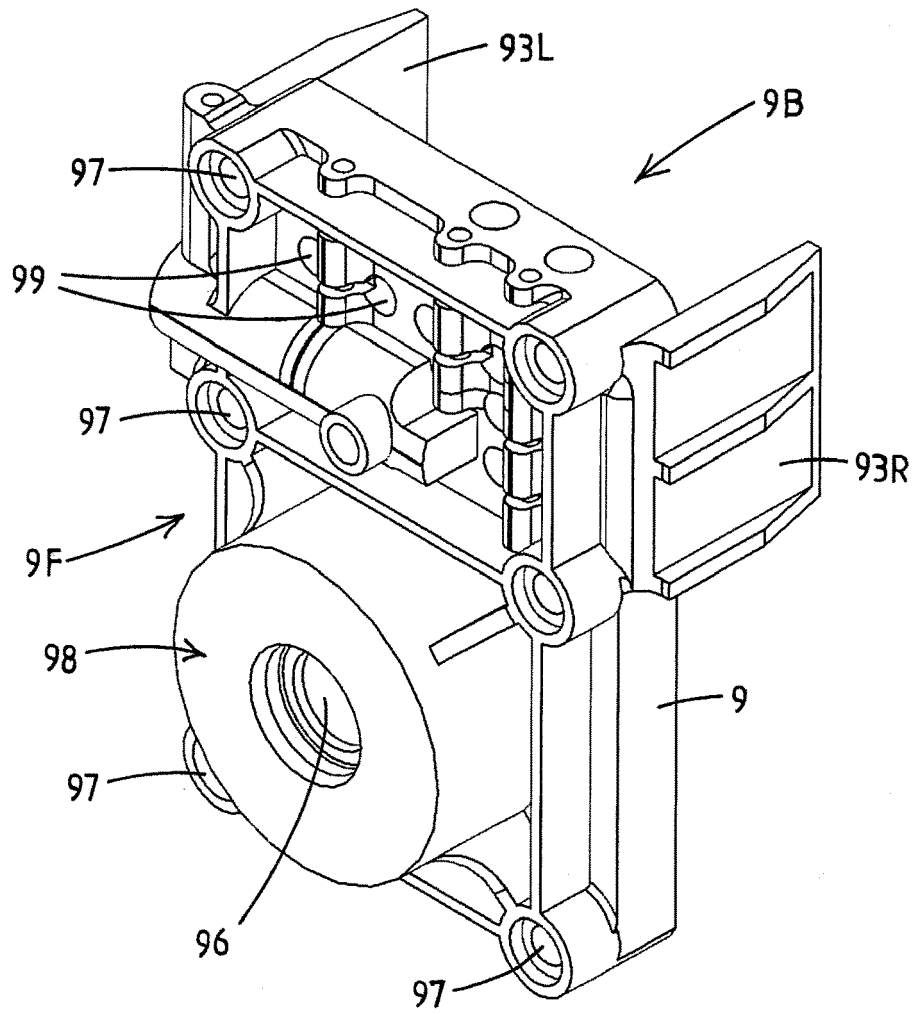


Fig.22

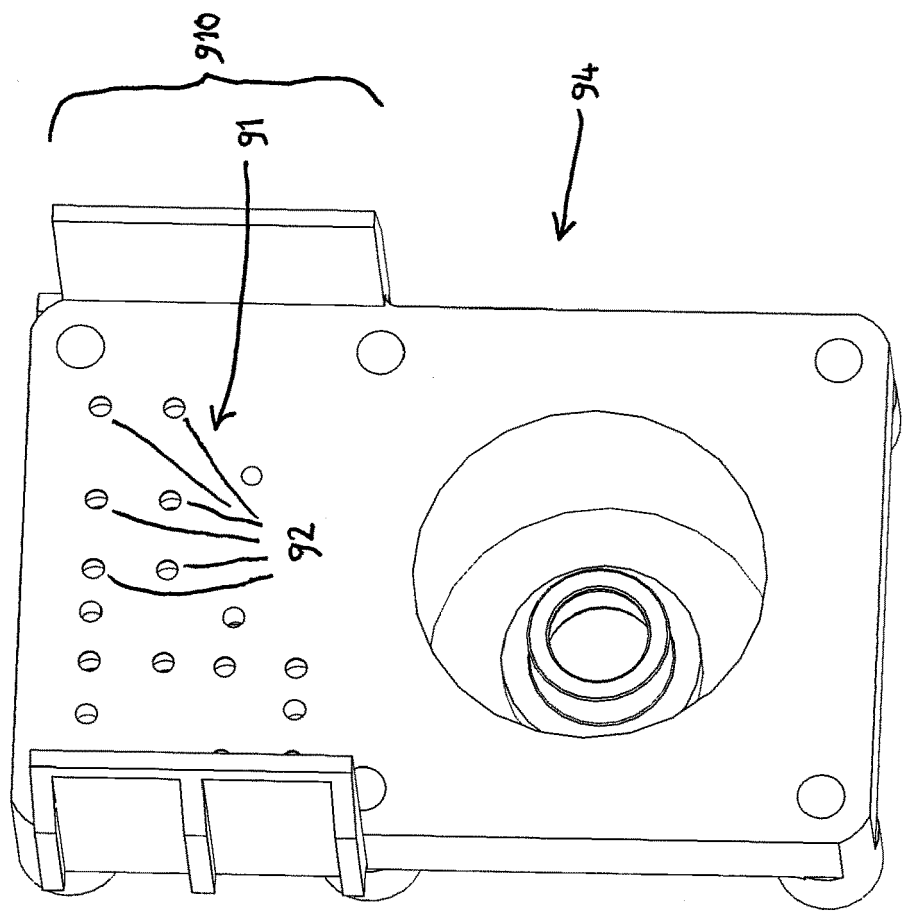


Fig.23

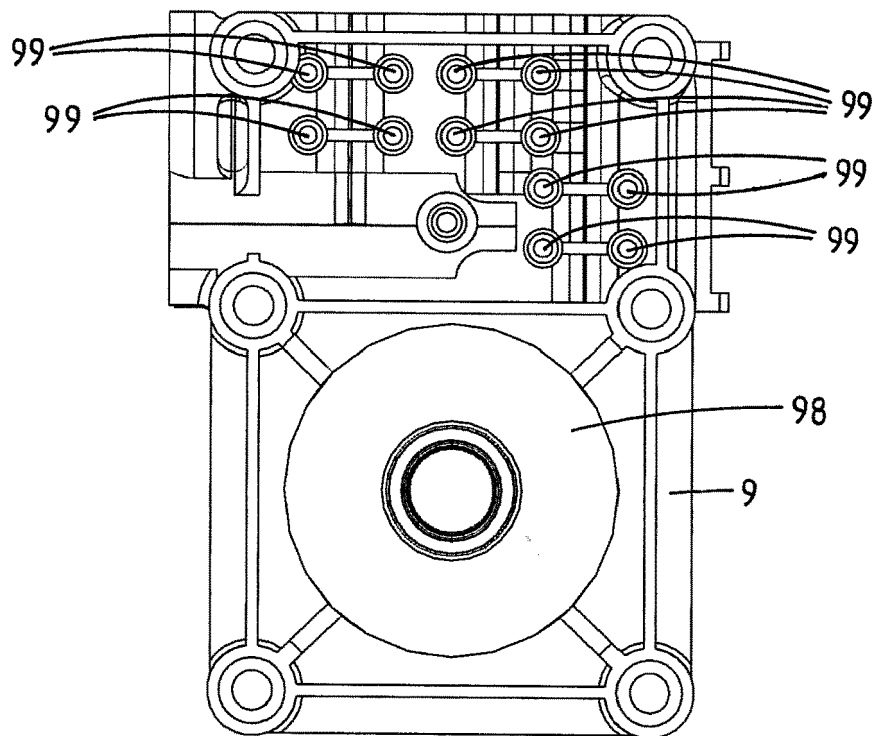


Fig.24

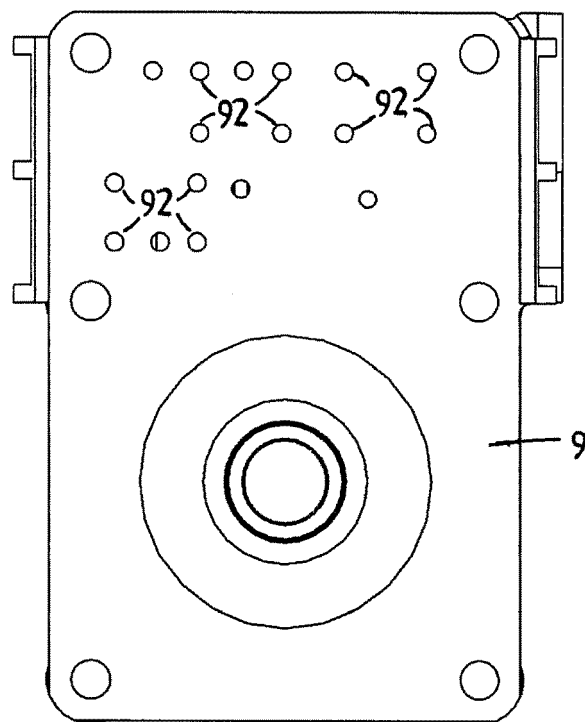


Fig.25

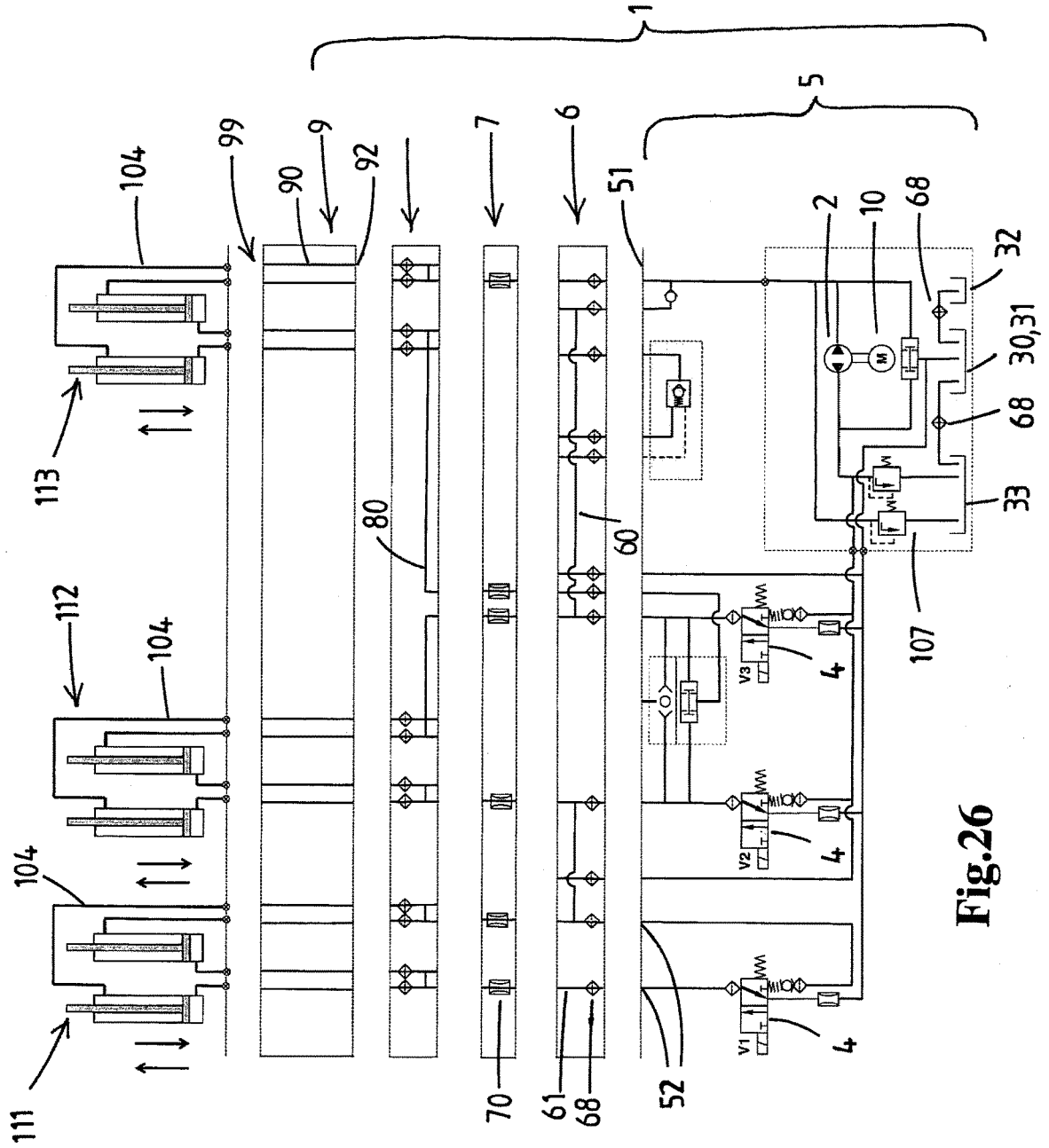


Fig. 26

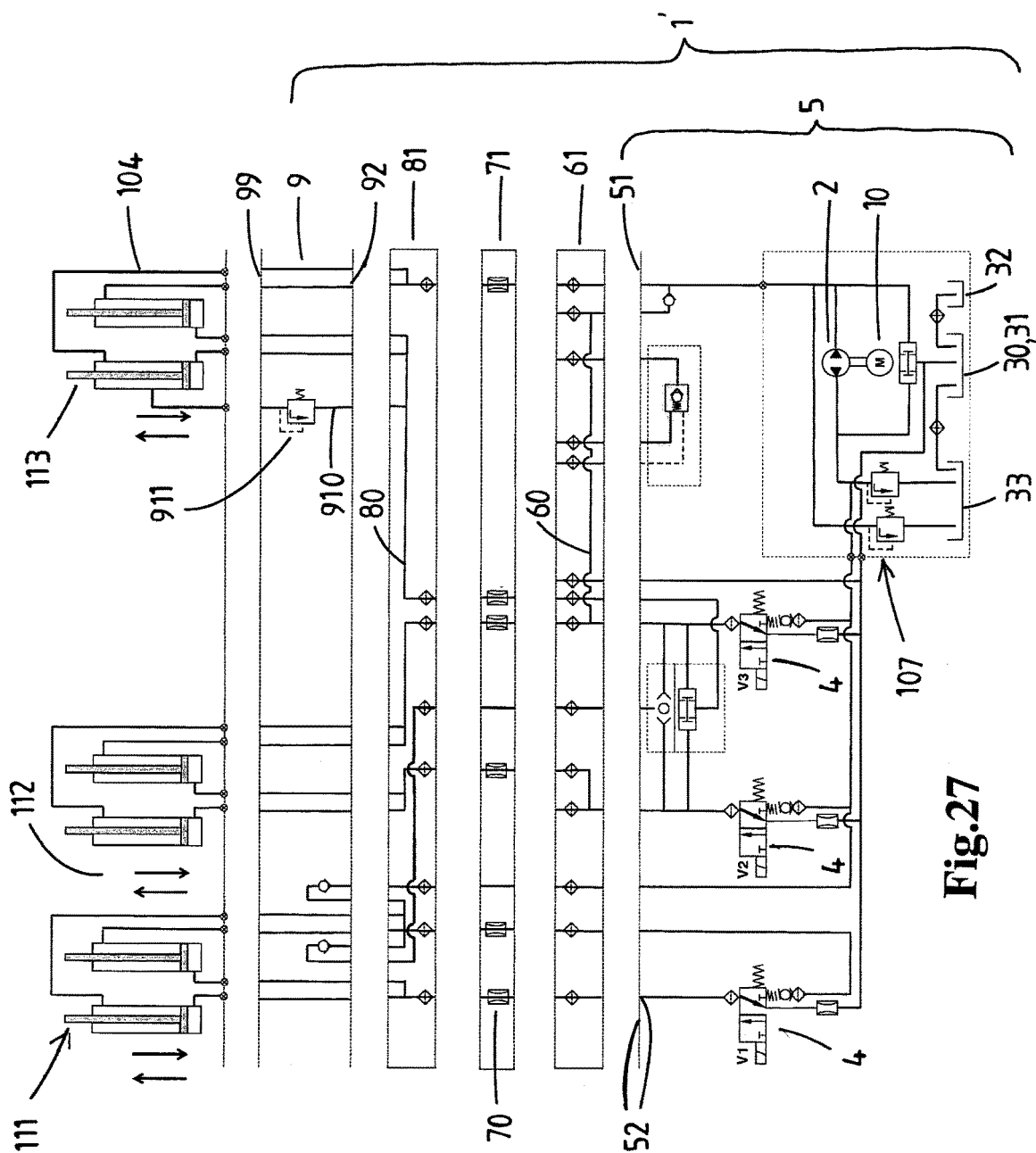


Fig.27

Fig. 28

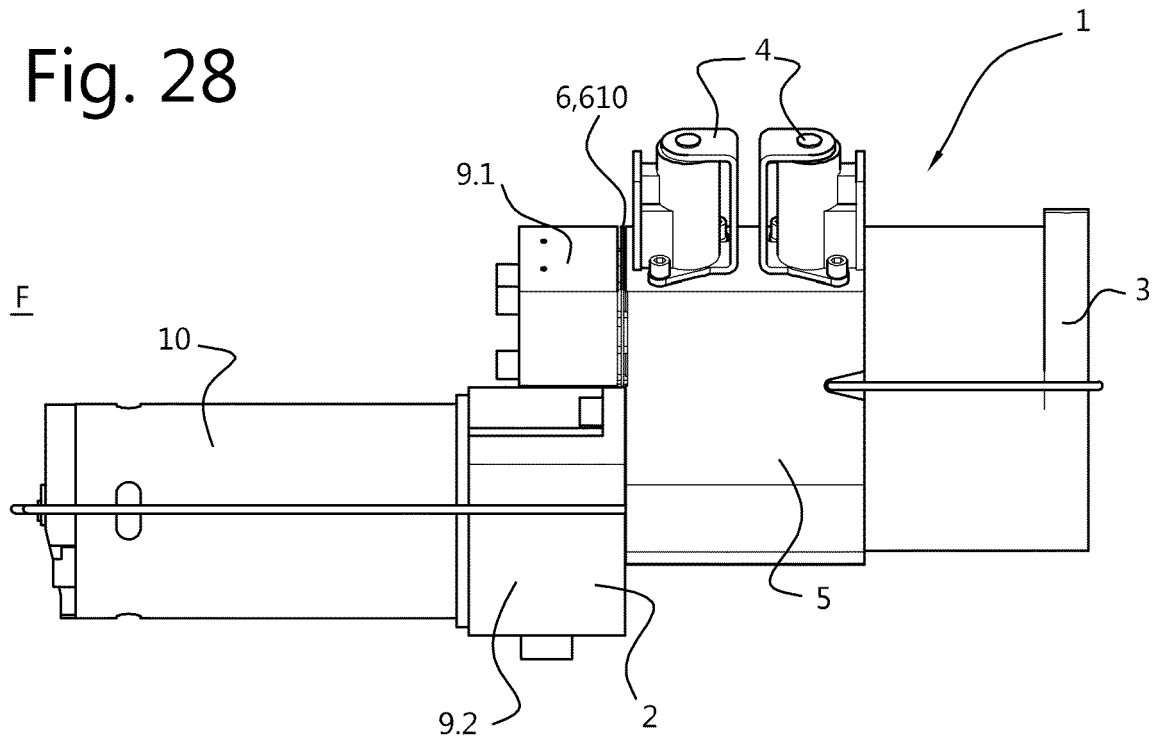
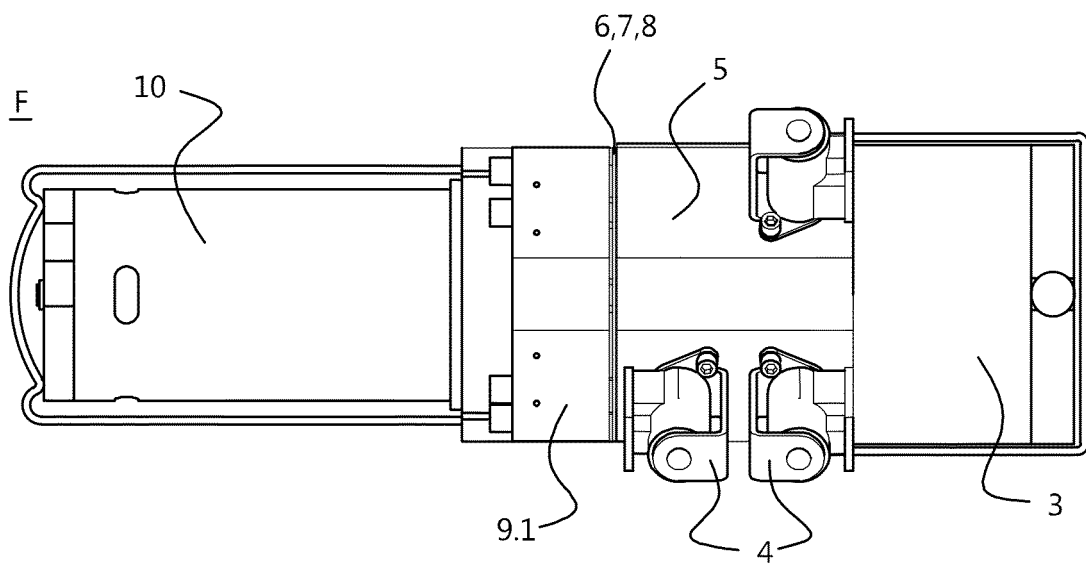
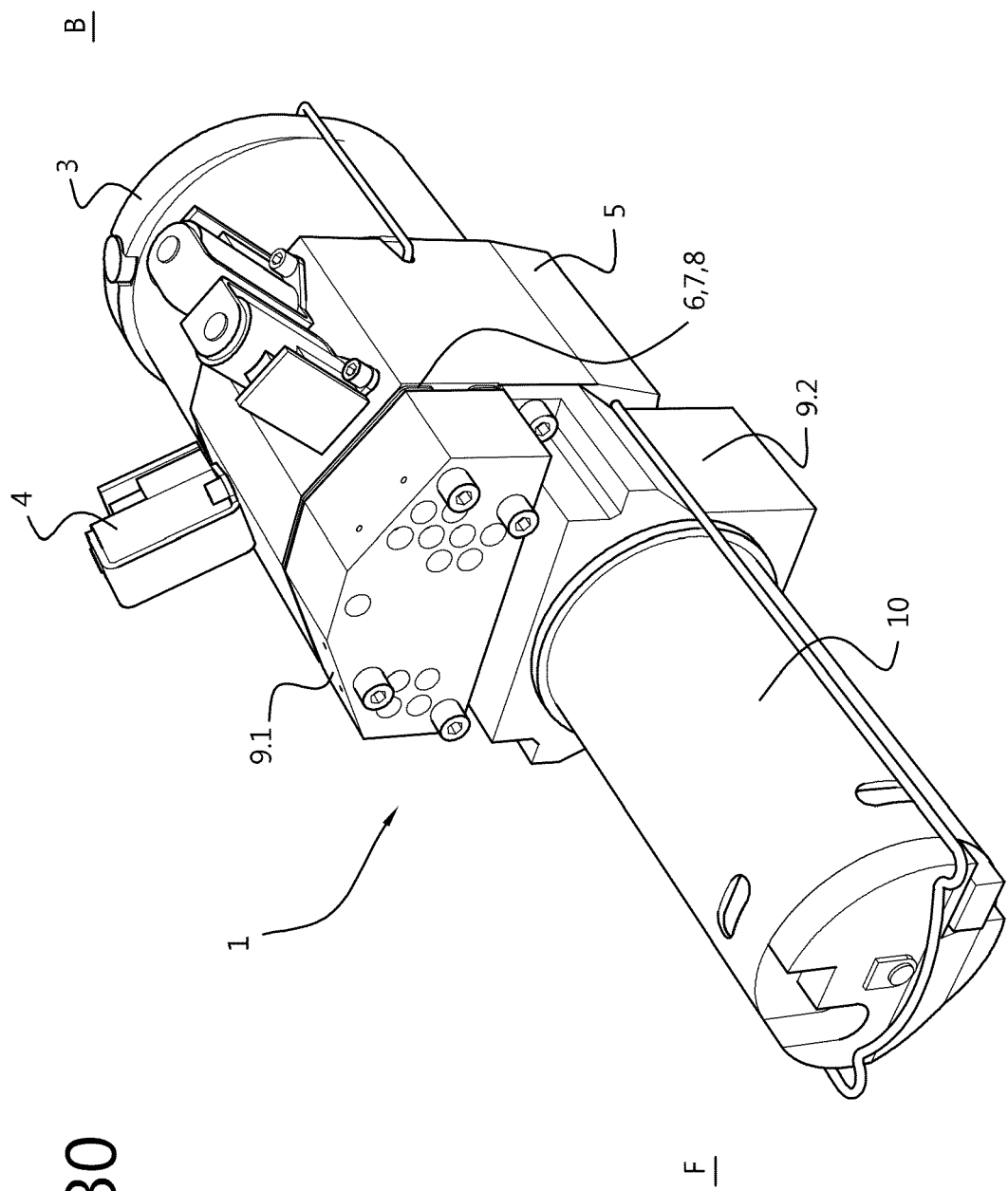


Fig. 29





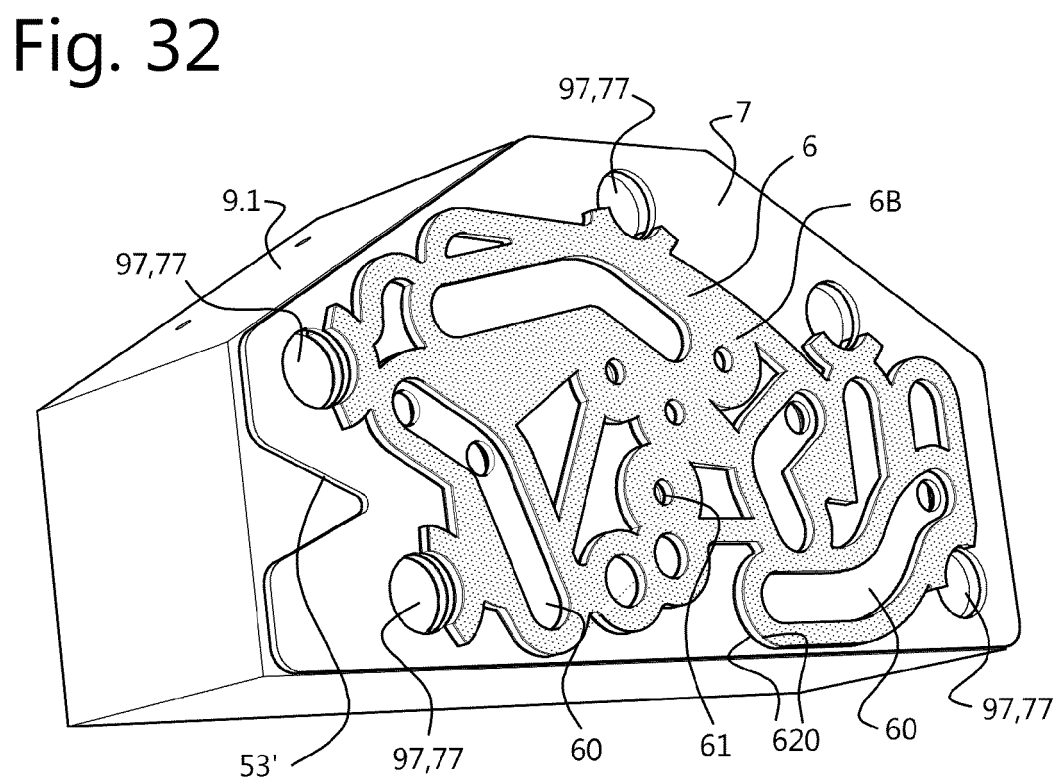
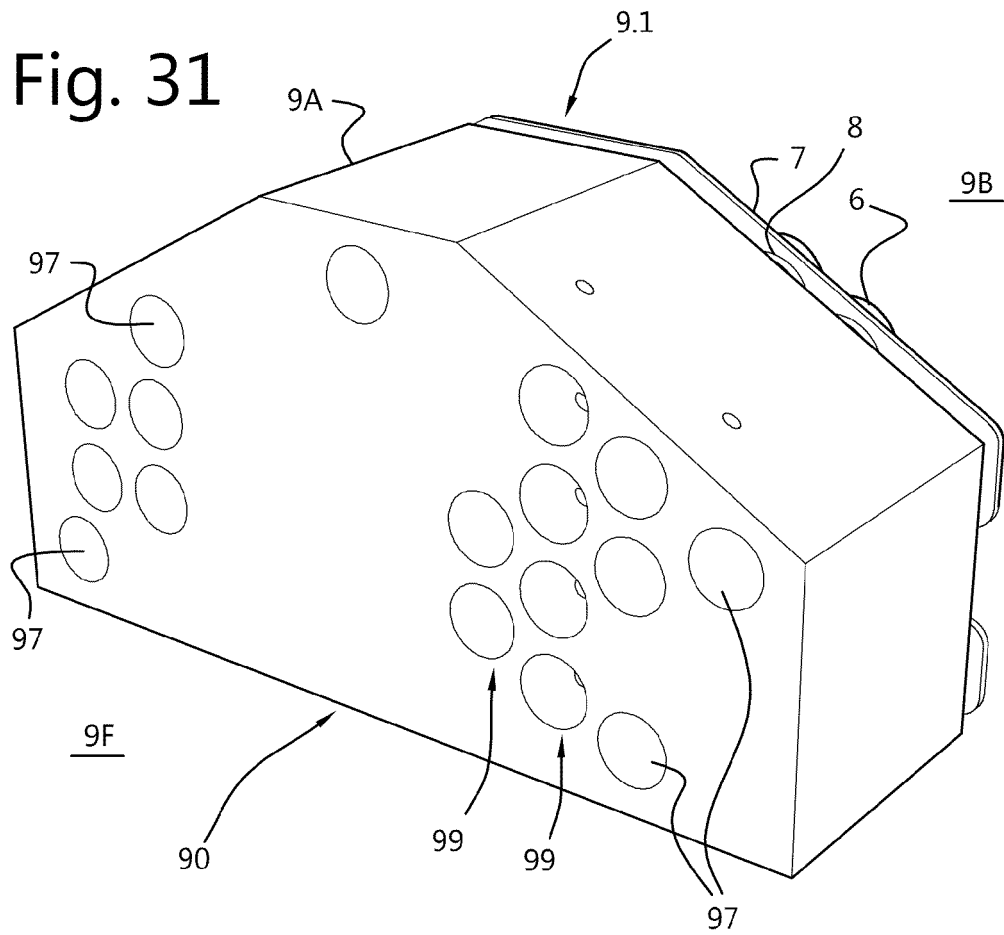


Fig. 33

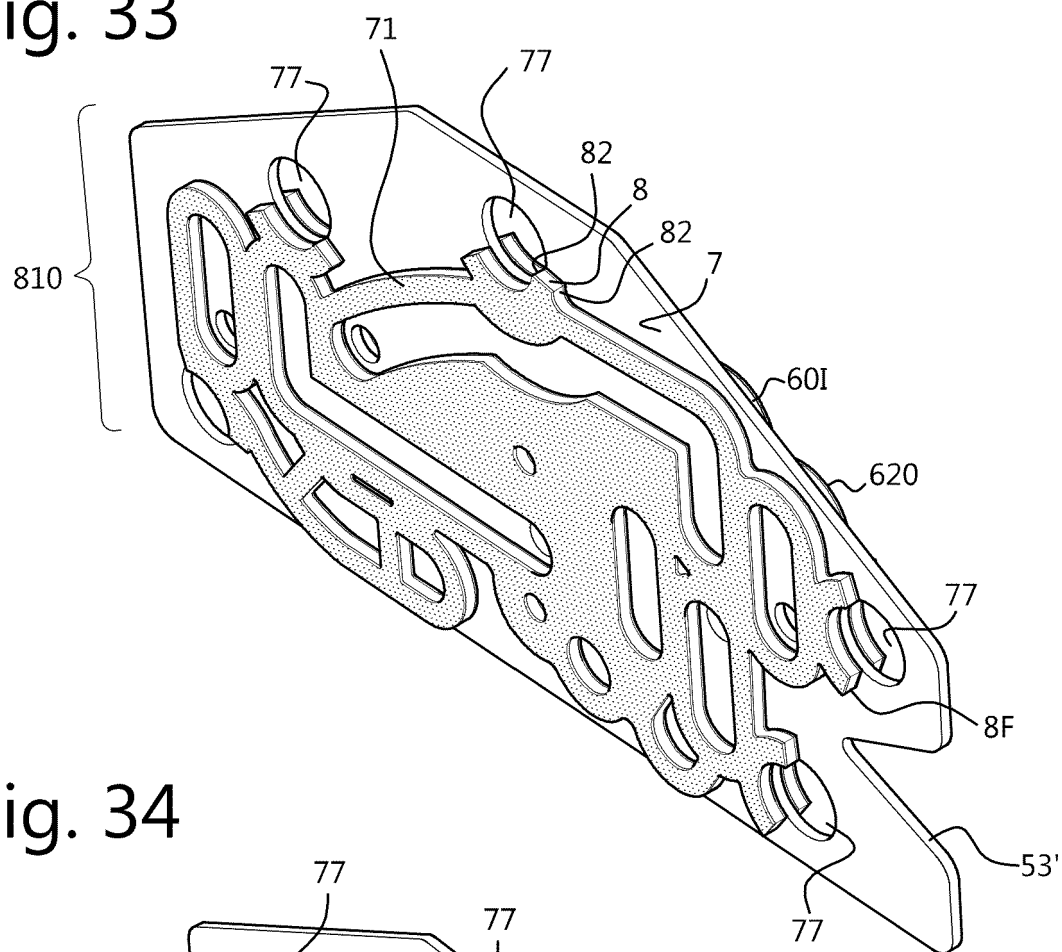
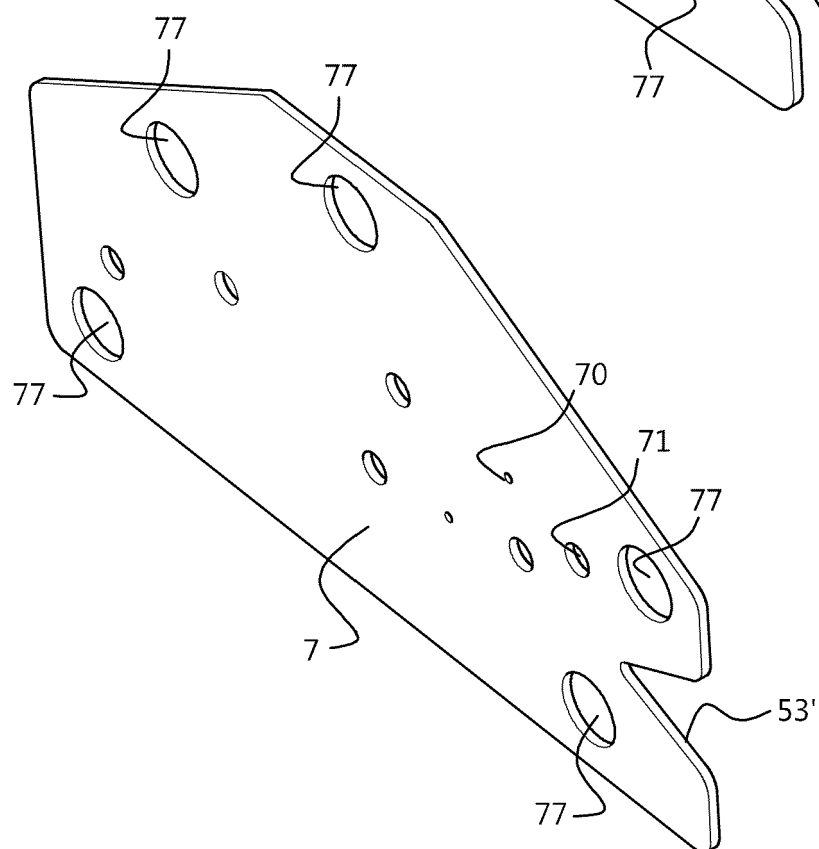


Fig. 34





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Place of search Munich		Date of completion of the search 17 December 2018	Examiner Lange, Christian
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