

Driving and control device for a vacuum pump, vacuum pump, and method for producing a control circuit board for a vacuum pump

The invention relates to a driving and control device for a vacuum pump, a vacuum pump, and a method for providing a control circuit board for a vacuum pump.

Vacuum pumps have at least one rotor element in a pump housing. With a turbomolecular pump, for example, this is a rotor with a plurality of rotor blades formed in rotor discs. For example, the rotor element may also be a substantially hollow cylindrical rotor of a Holweck stage. The at least one rotor element is carried by a rotor shaft rotatably supported in the pump housing. Further, at least one stator element is arranged in the pump housing, which cooperates with the at least one rotor element. With a turbomolecular pump, the stator element is formed by a plurality of disc-shaped stator discs with blades, which are arranged between adjacent rotor discs. With a Holweck stage, the stator element is a stationary helical groove. Further, a vacuum pump has a driving device which typically is an electric motor. In this respect the motor rotor is conventionally arranged directly on the rotor shaft. In particular for the realization of compact pump structures, the motor stator is arranged in a region of the vacuum pump in which vacuum prevails. As a consequence, a power supply has to be guided into the vacuum region for example through a separating wall of the pump housing. For a vacuum-tight current lead-through it is known to pass posts or pins through the separating wall for conducting electricity so that an electric conductor can be connected to the pin on both sides. For a vacuum-tight sealing, the pin is cast in glass or another suitable encapsulation mass. With such an encapsulation sufficient tightness can be ensured even when pressure differences exist between the two sides of the separating wall.

The connection of the pin to a control means located outside the vacuum region is made by a flexible line. In this case, providing a flexible line is necessary, since the glass encapsulation of the pin is extremely susceptible to mechanical tensions. Such tensions may for example occur due to tolerances in particular between pins and connectors. This would result to damages to the glass encapsulation upon assembly, if no flexible line were provided. However, providing such a flexible line means a substantial effort with respect to manufacture and in partic-

ular with respect to assembly. Plugging a corresponding plug contact with a flexible line onto the pins of the current lead-through must be made by hand. Here, great care has to be taken in particular that the glass encapsulation is not damaged by excessive forces. Therefore, manufacture and assembly are costly. Further, a rather large space is required.

It is an object of the present invention to simplify the connection to a current lead-through.

The object is achieved according to the invention with a driving and control device for a vacuum pump as defined in claim 1, a vacuum pump as defined in claim 10, as well as a method for manufacturing and assembling a control circuit board for a vacuum pump as defined in claim 11.

The driving and control device for a vacuum pump of the present invention has a separating wall or a base wall. In particular, the same is a part of the vacuum pump housing or a part adapted to be connected to the vacuum pump housing. The separating wall provides a separation of a vacuum region in the vacuum pump, in which the driving device such as the electric motor sensors and other electric components are arranged, and another region. This region may be a region outside the vacuum pump or another region situated in the vacuum pump, in which, however, a lower vacuum and in particular atmospheric pressure prevails. On one side of the separating wall the electric device is arranged in the vacuum region, while a control device is arranged on the other side of the separating wall, i.e. outside the vacuum region, where the control device may either be a control device arranged directly in a chamber of the vacuum pump, or an external control device.

The separating wall has a vacuum-tight current lead-through. Typically, this is formed by one or a plurality of pins or posts arranged in the separating wall in a vacuum-tight manner. This may in particular be effected by casting the pins in the separating wall, preferably by glass encapsulation. The current lead-through is connected to the electric device by a first current conductor. Typically, this is a flexible conductor, where the connecting wires are usually soldered to the pins. The connection between the current lead-through and the control device is made

via a second current conductor. According to the invention the second current conductor is configured as a plug contact directly connected to the current lead-through. Thereby, an exact, low-cost connection can be made in a simple manner. According to the invention the plug contact is connected to the control device via at least one connecting web.

In a development of the invention at least a part of the control device is configured as a control circuit board which may be connected to the separating wall. For example, the control circuit board is screwed or otherwise fastened directly on the side of the separating wall averted from the vacuum region in the vacuum pump.

In a particularly preferred embodiment of the invention a base plate or a base element is further provided. The same is preferably fastened to the separating wall, either directly or indirectly. In a particularly preferred embodiment the base plate or the base element serves to fasten the control circuit board. Further, in another preferred embodiment the plug contact may be fastened to the base plate or the base element.

In this preferred embodiment it is preferred for purposes of assembling that the control circuit board is first fixed to the base plate or base element in particular by screws. The plug contact or an element carrying the plug contact is then retained on the base plate or base element, preferably also by screws, but is not fixed yet so that the plug contact is still movable. In a next step the base plate or base element is connected to the separating wall, with the plug contact being plugged on the current lead-through. Due to the still loose connection between the plug connector and the base plate or base element, an induction of forces or moments into the current lead-through is avoided. Thereafter, the base plate or base element is fixed to the separating wall or another part of the pump or the pump housing. Only after this fixation and thus after the definition of the position of the control circuit board is the plug contact fixed on the base plate or base element in particular by tightening the corresponding screws. Thereby, it is ensured that possible existing tolerances are compensated before the plug contact is fixed. The plug contact is fixed only after the tolerances are compensated.

In both above embodiments in which the control circuit board is fixed either on the separating wall or the base plate, it is preferred that the plug contact is connected to the control circuit board via a flexible cable that is a part of the second current conductor. Further, it is preferred, in particular under aspects of simplifying assembly, that the plug contact is connected to the control circuit board via at least one connecting web. In particular this is advantageous in that the positioning of the plug contact as well as of the other electronic components arranged on the circuit board can also be made automatically.

The at least one connecting web is directly connected to the plug contact or a carrier plate is provided in addition. The carrier plate is connected to the control circuit board via at least one connecting web, with the carrier plate carrying the plug contact. The carrier plate may be a part of a plate-shaped main carrier of the circuit board. Here, the carrier plate may for example be made by a corresponding recesses in the circuit board so that only the at least one connecting web is left. In this particularly preferred embodiment the carrier plate can be made in a particularly simple manner and the plug contact may be positioned in the carrier plate in a simple manner, in particular automatically.

In a preferred embodiment, the at least one connecting web has a certain flexibility. This may be achieved by a relatively thin design of the at least one connecting web. It is particularly preferred that the at least one connecting web can be severed. It is thus possible to cut the at least one connecting web in particular before the assembly of the control circuit board on the base plate or the separating wall. Thereby, it becomes possible to securely fasten the carrier plate that carries the plug contact on the base plate or the separating wall, e.g. by a screw fastening. This is also possible for the control circuit board.

For compensation of tolerances, it is preferred when assembling the control circuit board on the separating wall that the control circuit board first rests on the separating wall, while simultaneously plugging the plug contact on the pins of the current lead-through. In the next step the plug contact, in particular the carrier plate of the plug contact, can be fixedly connected to the separating wall e.g. by the screw connection, with the at least one connecting web possibly being severed before this connection. In the next step the control circuit board may be

securely fixed to the separating wall, in particular also by means of a screw connection.

For compensation of the tolerances, when mounting the control circuit board on the base plate, the control circuit board is first fastened on the base plate. Then the plug contact or the carrier plate is loosely fastened on the base plate, without a final fixation. The, the base plate is fixedly connected to the separating wall, either directly or indirectly, in particular by screw connections, with the plug contact loosely connected to the base plate being plugged on before. Here, a severing of the at least one connecting web is done in particular prior to this step. Thereafter, the base plate or the base element is fastened on the separating wall and finally the plug contact or the carrier plate of the plug contact is fixed on the base plate.

In both above described variants of fastening the control circuit board, no forces and tensions are induced into the current lead-through via the plug contact, provided the connecting webs are flexible or severed. Occurring tolerances that could lead to tensions are compensated by the present invention design of the plug contact arranged in particular on the carrier plate, in combination with severable or flexible connecting webs.

Further, the invention relates to a vacuum pump with a rotor shaft arranged in a pump housing and in particular supported in rotatable manner. The shaft carries at least one rotor element. Further, at least one stator element is arranged in the pump housing, cooperating with the rotor element. Further, according to the invention and corresponding to the driving and control device, a separating wall is provided for defining a vacuum region. The separating wall also comprises a current lead-through with e.g. pins or the like. The drive device and/or other electric devices are arranged on one side of the separating wall which in particular is a part of the pump housing, while the control device is arranged on the other side. Here, the electric device is arranged in a vacuum region of the pump, while the control device is arranged in a region with a lower vacuum, in particular atmospheric pressure. According to the invention, as described above with reference to the driving and control device, a first current conductor is connected to the driving device and a second current conductor is connected to the control device, the

second current conductor having a plug contact directly connected to the current lead-through. The vacuum pump of the present invention is preferably developed as described above with reference to the different embodiments of the driving and control device. The individual above described features of the driving and control device thus also represent preferred features of the vacuum pump of the invention.

The invention further relates to a method for manufacturing and mounting a control circuit board for a vacuum pump.

First, a circuit board carrier with a main carrier and a carrier plate is made. The main carrier of the circuit board carrier serves to receive electronic components and the like. The carrier plate serves to receive plug contacts and, according to the invention, is connected to the main carrier by at least one connecting web.

After manufacture of the circuit board carrier, the main carrier is equipped with electronic components, which is done, in a preferred embodiment, in an automatic or automated manner. Thereafter, a plug contact is arranged on the carrier plate which may preferably also be done in an automatic or automated manner. According to the invention the at least one connecting web is severed for or during assembly. Thereby, the tolerance compensation described above with reference to the driving and control device of the present invention and to the vacuum pump of the present invention can be achieved in a simple manner.

For the manufacture of the circuit board carrier it is preferred for example to make the same from an integral flat carrier material that is generally used for electronic circuit boards, where the carrier plate receiving the plug contact is manufactured such that recesses are formed. Here, the recesses are formed such that at least one connecting web is left to hold the carrier plate. The recesses may be made by milling, cutting or the like.

The control circuit board, i.e. the main carrier and/or the carrier plate, is preferably mounted as described above on the separating wall that delimits a vacuum region or on the base plate. Here, as described above with reference to the vac-

uum pump, the plug contact is preferably plugged directly onto the current lead-through or the corresponding pins.

The method is developed in an advantageous manner as described above with reference to the different embodiments of the driving and control device, as well as to the vacuum pump.

The invention will be described in detail with reference to preferred embodiments and to the accompanying drawings.

In the Figures:

Figure 1 is a schematic sectional view of a driving and control device mounted on a base plate,

Figure 2 is a schematic top plan view of a control circuit board and a plug contact,

Figure 3 is a schematic sectional view of a driving and control device mounted on a separating wall,

Figure 4 is a schematic sectional view of a further embodiment of a control circuit board and a plug contact,

Figure 5 is a schematic sectional view of the control circuit board and the plug contact illustrated in Figure 4, and

Figure 6 is a schematic sectional view of the control circuit board illustrated in Figure 5, with the plug contact in place.

In the first embodiment illustrated (Figures 1 and 2), a control device has a plurality of only schematically illustrated electronic components 10 arranged on a circuit board 12. The circuit board 12 is connected for example to a frequency converter, an additional control device or the like. A schematically illustrated driving device 14, such as an electric motor, is provided to drive the vacuum pump. Here, the electric motor is typically connected directly to the rotor shaft of

the vacuum pump to be driven. Instead of the electric motor, this may be a temperature sensor, rotational speed sensor and/or another electronic device. With respect to a separating wall 16 of the vacuum pump, the electronic device is arranged in a region 18 in which a vacuum prevails. The separating wall separates the vacuum region 18 in particular tightly from a region 20 in which a lower vacuum or in particular atmospheric pressure prevails. The device 14 is connected to pins 24 via current conductors 22. The pins 24 penetrate the separating wall and thus represent a current lead-through. For sealing purposes, the pins 24 are cast for example in glass 26.

In the region 20 where in particular atmospheric pressure prevails, the pins 24 are connected to a plug contact 28. The plug contact is arranged on a carrier plate 30, for example glued thereon. For an electric connection, the carrier plate 30 is connected to the control circuit board 12 via a flexible cable which in the embodiment illustrated is a ribbon cable 32. In the embodiment illustrated, the carrier plate 30 is fixed to a base plate 25 by means of a screw 34. Since, after assembly, the connection to the control circuit board 12 is effected only via the flexible ribbon cable 32 in the embodiment illustrated, the control circuit board 12 induces no forces into the carrier plate 30 and thus no forces are induced to the pins 24. It is thereby ensured that the encapsulation 26 is not damaged by corresponding forces or tensions. The base plate 35 is connected to the separating wall 16 by screws 37.

In this preferred embodiment of the invention, for mounting, the control circuit board 12 is first fixed on the base plate 35 using the screws 38. Thereafter, the screw 34 is slightly screwed into the plug contact 28, while the plug contact 28 is not fixed yet so that it is still movable. In the next assembly step, the base plate 35 is set or plugged on the separating wall 16, where, for example, centering protrusions, centering pins or the like may be provided. Here, the plug contact 28 is plugged onto the pins 24. Since the plug contact 28 is not fixed yet, plugging may be made without corresponding forces or tensions being induced into the encapsulation 26, which might damage the encapsulation. With this fixation, it is still possible to slightly displace the plug contact 28. After fixation of the base plate 35, the plug contact 28 may also be fixed using the screw 34.

For manufacturing the control circuit board 12, the same has a circuit board carrier 42 (Figure 2). The electronic components 10, as well as conductor paths etc. are arranged thereon. For being equipped, the carrier plate 30 of the embodiment illustrated is connected to the circuit board carrier 42 via four connecting webs 44. Thereby, it is possible to also position the plug 28 in an automatic or automated manner. Before or during assembly on the base plate 35, the connecting webs 44 are severed.

In another preferred embodiment (Figure 3) similar or identical components are identified by the same reference numerals.

The essential difference of this embodiment is that the control circuit board 12 and the plug contact 18 are not arranged on a base plate 35 (Figure 1) but on the separating wall 16. The control circuit plate 12 is connected to the carrier plate 30 via webs 44, as illustrated in Figure 2. Further, a ribbon cable 32 is provided for electric contacting purposes. For assembly, the webs 44 are severed in order to prevent the transmission of forces from the carrier plate 30 and thus into the encapsulation mass 26.

For assembly, the control device 12 is first fixed on the separating wall 16 by means of screws 33. At the same time, the plug contact 28 is plugged onto the pins 24 without being fixed yet. The plug contact 28 is fixed only after the control circuit board 12 is fixed on the separating wall 16 by means of the screws 33. Then, the plug contact 28 is fixed by means of screws 29.

Figures 4 – 6 illustrate another preferred embodiment of a control circuit board, as well as of a plug contact. This is an independent invention which, as discussed above with reference to the two embodiments, may possibly be connected to a separating wall 16 or a base plate 35. The control circuit board 46 illustrated in Figures 4 – 6 is also equipped with a plurality of electronic components 10. A carrier plate 48 is arranged outside the control circuit board 46. Possible, connecting webs 52 may be provided for equipping a circuit board carrier 50, as well as the carrier plate 48, the webs then being severed for assembly. However, these connecting webs 52 may also be omitted. Conductors 54 which may also be designed as ribbon cables connect the control circuit board 46 to the carrier plate 48 or a plug contact 28 arranged on the carrier plate 48. Possibly, the car-

rier plate or the circuit board 48 may be omitted. In this embodiment, the conductors 54 or a corresponding ribbon cable is directly connected to the plug contact 28.

In particular, if connecting webs 52 are provided, an automatic equipping of the circuit board 46, as well as of the carrier plate 48 can be performed. For assembly, the webs 52, if present, are severed and the carrier plate 48, together with the plug contact 28, is moved from the position illustrated in Figure 5 into the position illustrated in Figure 6. For this purpose, the circuit board carrier 50 is provided with passage bores 56. Substantially cylindrical projections 58 of the plug contact 54 are inserted through the bores 56 for assembly, the diameter of the bores 56 being larger than that of the cylindrical protrusions 58. For assembly, the plug contact 28 may then be fixed on a separating wall 16 or a base plate 35 by means of screws, as described for the above embodiments. This may be done with two screws 60. Upon assembly, the plug contact 28 is again plugged onto the pins 24, where an induction of forces or tensions into the encapsulation 26 is avoided due to the mechanical separation of the plug contact 28 and the control circuit board 46.

Claims

1. Driving and control device for a vacuum pump having

an electric device (14) arranged in a vacuum region (18) of a vacuum pump,

a control device (12, 46) arranged outside the vacuum region (18) of the vacuum pump,

a separating wall (16) for delimiting the vacuum region (18) and

a current lead-through (24) arranged in the separating wall (16) in a vacuum-tight manner and connected to the electric device (14) via first current conductors (22) and to the control device (12, 46) via second current conductors (28, 32),

characterized in that

the second current conductor (28, 32) has a plug contact (28, 58) directly connected to the current lead-through (24), the plug contact, prior to assembly, being connected to the control device (12) via at least one connecting web (44).
2. Driving and control device of claim 1, characterized in that the control device (12, 46) has a control circuit board (12, 46) connected to the separating wall (16).
3. Driving and control device of claim 2, characterized in that the plug contact (28, 58) is fastened on the separating wall (16).
4. Driving and control device of claim 1, characterized in that the control device (12, 46) is fastened to a base plate (35) which preferably is fastened on the separating wall (16).

5. Driving and control device of claim 4, characterized in that the plug contact (28, 58) is fastened on the base plate (35).
6. Driving and control device of one of claims 2 - 5, characterized in that the plug contact (28, 58) is connected to the control circuit board (12, 46) via a flexible conductor (32).
7. Driving and control device of one of claims 2 - 6, characterized in that the at least one connecting web (44, 52) of the plug connector (28, 58) is connected to the control circuit board (12, 46).
8. Driving and control device of claim 7, characterized in that the plug contact (28, 58) is arranged on a carrier plate (30) and the connecting webs (44, 52) are connected to the carrier plate (30).
9. Driving and control device of claim 7 or 8, characterized in that the connecting webs (44, 52) are severed for a tolerance-compensating assembly.
10. Vacuum pump comprising
 - a rotor shaft arranged in a pump chamber, the shaft carrying at least one rotor element,
 - at least one stator element arranged in the pump housing and cooperating with the at least one rotor element,
 - an electric device (14) arranged in a vacuum region (18) of the vacuum pump,
 - a control device (12, 46) arranged outside the vacuum region (18) of the vacuum pump,
 - a separating wall (16) for delimiting the vacuum region (18), and
 - a current lead-through (24) arranged in the separating wall (16) in a vacuum-tight manner and connected to the electric device (14) via first current

conductors (22) and to the control device (12, 46) via second current conductors (28, 32),

characterized in that

the second current conductor (28, 32) has a plug contact (28, 58) directly connected to the current lead-through (24), the plug contact, prior to assembly, being connected to the control device (12) via at least one connecting web (44).

11. Method for manufacturing and mounting a control circuit board for a vacuum pump, the method comprising the following steps:

manufacturing a circuit board carrier having a main carrier (42, 50) and a carrier plate (30, 48) connected to the main carrier (42, 50) via at least one connecting web (44, 52),

equipping the main carrier (42, 50) with electronic components (10),

arranging a plug contact (28, 59) on the carrier plate (30, 48), and

severing the at least one connecting web (44, 52) for or during assembly.

12. Method of claim 11, wherein the main carrier (42, 50) and/or the carrier plate (30, 48) is assembled to a separating wall (16) or a base plate (35) of a driving and control device of one of claims 1 – 9, the plug contact (28, 59) preferably being connected directly to the current lead-through (24), in particular by being plugged onto or into the same.
13. Method of claim 11 or 12, wherein the plug contact (28, 58) is fastened to the base plate (35) in particular from an outer side after having been plugged onto the current lead-through (24).