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Vor Ablauf der für Änderungen der Ansprüche zugelassenen Frist; Veröffentlichung wird wiederholt falls Änderungen eintreffen.

(54) Title: GAS-DYNAMIC PRESSURE-WAVE MACHINE

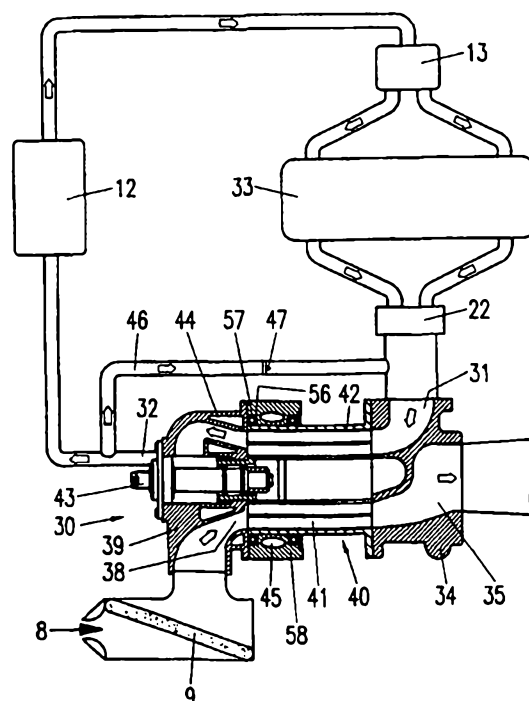
(54) Bezeichnung: GASDYNAMISCHE DRUCKWELLENMASCHINE

(57) Abstract

The invention concerns a gas-dynamic pressure-wave machine for supplying an internal combustion engine with charge air. Said machine comprises a rotor (6, 40) comprising cells (18, 41), a low pressure fresh air supply duct (14, 38), a high pressure charge air supply duct (10, 32) leading to the internal combustion engine (1, 33), and a high pressure exhaust gas duct (3, 31) originating from the internal combustion engine and a low pressure exhaust gas duct (4, 35). Said low pressure exhaust gas duct (4, 35) and said high pressure exhaust gas duct (3, 31) are arranged in a gas casing (5, 34), and said low pressure fresh air supply duct (14, 38) and said high pressure charge air supply duct (10, 32) are arranged in an air casing (15, 39). In order to eliminate harmful pressure pulsation and to increase the compression efficiency level, between the high pressure charge air supply duct (32) and the high pressure exhaust gas duct (31) has been placed a direct connection conduit (41), preferably comprising a non-return valve (47).

(57) Zusammenfassung

Die gasdynamische Druckwellenmaschine, die bestimmt ist, einer Verbrennungsmaschine Ladeluft zuzuführen, weist einen Zellen (18, 41) aufweisenden Rotor (6, 40), einen Niederdruck-Frischluftezufuhrkanal (14, 38), einen zur Verbrennungsmaschine (1, 33) führenden Hochdruck-Ladeluftkanal (10, 32), einen von der Verbrennungsmaschine herkommenden Hochdruck-Abgaskanal (3, 31) und einen Niederdruck-Abgaskanal (4, 35) auf, wobei der Niederdruck-Abgaskanal (4, 35) und der Hochdruck-Abgaskanal (3, 31) in einem Gasgehäuse (5, 34) und der Niederdruck-Frischluftezufuhrkanal (14, 38) und der Hochdruck-Ladeluftkanal (10, 32) in einem Luftgehäuse (15, 39) angeordnet sind. Um einerseits die schädlichen Druckpulsationen zu beseitigen und andererseits den Kompressions-Wirkungsgrad zu erhöhen, ist zwischen dem Hochdruck-Ladeluftkanal (32) und dem Hochdruck-Abgaskanal (31) eine direkte Verbindungsleitung (46) angeordnet, die vorzugsweise ein Rückschlagventil (47) aufweist.



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Abstract of the Disclosure

The gas-dynamic pressure wave machine which is destined for the charge air supply of an internal combustion engine comprises a rotor (6, 40) with cells (18, 41), a low pressure fresh air inlet channel (14, 38), a high pressure charge air channel (10, 32) leading to the internal combustion engine (1, 33), a high pressure exhaust channel (3, 31) coming from the internal combustion engine, and a low pressure exhaust channel (4, 35), the low pressure exhaust channel (4, 35) and the high pressure exhaust channel (3, 31) being enclosed in a gas enclosure (5, 34) and the low pressure fresh air inlet channel (14, 38) and the high pressure charge air channel (10, 32) being enclosed in an air enclosure (15, 39). In order to eliminate the detrimental pressure pulsations, on one hand, and to increase the compression efficiency, on the other hand, a direct connection (46) is provided between the high pressure charge air channel (32) and the high pressure exhaust channel (31), which connection preferably comprises a nonreturn valve (47).

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25 (FIG. 2)



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GAS-DYNAMIC PRESSURE WAVE MACHINE

The present invention refers to a gas-dynamic pressure wave machine which is destined for the charge air supply of an internal combustion engine, comprising a rotor with cells, a low pressure fresh air inlet channel, a high pressure charge air channel leading to the internal combustion engine, a high pressure exhaust channel coming from the internal combustion engine, and a low pressure exhaust channel, the low pressure exhaust channel and the high pressure exhaust channel being enclosed in a gas enclosure and the low pressure fresh air inlet channel and the high pressure charge air channel being enclosed in an air enclosure. A pressure wave machine of this kind is known from the prior art, e.g. from CH-A-681 738.

Since the concept of the pressure wave machine of the prior art only allows a high efficiency in conjunction with a constant-pressure system which is as free of pulsations as possible, a volume is integrated in the exhaust manifold prior to the pressure wave machine in order to damp the motor pulsations. Without this damping action, the hard motor pulsations would enter the rotor through the exhaust channel of the gas enclosure, especially at lower motor speeds, and interfere with the proper pressure wave process of the pressure wave machine, resulting in a significant decrease in efficiency and to increased recirculation. The relatively large volume integrated in the exhaust manifold in front of the pressure wave machine is only capable of damping the pulsations partly, but not of eliminating them. Also, such an exhaust manifold volume is disadvantageous because of the larger construction volume and the higher heat capacity.



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For high charging pressures and a high efficiency, standard pressure wave machines strongly depend on the filling degree. In the case of a low flow rate in the internal
5 combustion engine, the filling degree of the rotor of the pressure wave machine will decrease and therefore also the charging pressure. In fact, in this area of the performance field, the machine is too big. In the case of a high flow
10 rate in the internal combustion engine, the degree of filling strongly increases, and the compression efficiency deteriorates. Consequently, in this area of the performance field, the pressure wave machine is too small.

On the background of this prior art, it is the object of the
15 present invention to provide a pressure wave machine which allows to eliminate the detrimental pulsations and to increase the compression efficiency with a reduced volume of the exhaust manifold. This object is attained by a pressure wave machine wherein a connection is provided between the
20 high pressure charge air channel and the high pressure exhaust channel.

The invention will be explained in more detail hereinafter with reference to a drawing of exemplary embodiments.
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FIG. 1 schematically shows a developed cylindrical section through the cells of the rotor of a pressure wave machine according to the prior art;

30 FIG. 2 shows a general view of a gas-dynamic pressure wave machine of the invention; and



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FIG. 3 shows a perspective view of the gas-dynamic pressure wave machine of FIG. 2.

For the sake of simplicity, a single pressure wave cycle is described and represented in the developed view of FIG. 1 while Figs. 2 and 3 show a two-cycle machine. However, the invention is independent from the number of pressure wave cycles, and it may be applied to pressure wave machines having a single cycle or two or more cycles.

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FIG. 1 shows a developed view of the rotor of a pressure wave machine according to the prior art, as well as internal combustion engine 1, gas-dynamic pressure wave machine 2, high pressure exhaust channel 3 and low pressure exhaust channel 4 including scavenging air S, rotor 6 with individual cells 18, fresh air inlet 8 resp. low pressure fresh air inlet channel 14, and high pressure charge air channel 10 which communicates with charge air passage 11 and leads to internal combustion engine 1.

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FIGS. 2 and 3 illustrate a gas-dynamic pressure wave machine according to the invention which comprises a number of improvements in order to essentially increase the overall efficiency. Pressure wave machine 30 is connected to schematically illustrated internal combustion engine 33 by high pressure exhaust channel 31 and high pressure charge air channel 32. Gas enclosure 34 further comprises low pressure exhaust channel 35, and this figure shows that the two channels, i.e. the high pressure exhaust channel and the low pressure exhaust channel, enter the gas enclosure on the rotor side in the form of sector-shaped openings having each an opening edge 36 and 37, respectively. Further illustrated is rotor 40 with its cells 41, the rotor being



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arranged in an envelope 42 and driven e.g. by means of a belt drive 43.

As already mentioned in the introduction, the exhaust
5 manifold volume used in the pressure wave machines of the prior art in order to damp the motor pulsations must be relatively large, but it is nevertheless incapable of eliminating the detrimental pulsations. The pressure wave machine represents an open system, i.e. there is a direct
10 connection between the exhaust section and the fresh air section through the rotor. However, this also transmits the motor pressure pulsations from the exhaust high pressure section to the fresh air high pressure section.

15 This drawback can now be eliminated by a direct fresh air supply to the exhaust channel. FIGs. 2 and 3 show the connection 46 leading from high pressure charge air channel 32 to high pressure exhaust channel 31, whereby the positive pressure pulses in the high pressure charge air channel are
20 transmitted to the high pressure exhaust channel. The connection comprises a nonreturn valve 47 comprising an electronic regulation, as the case may be. The nonreturn valve acts as a regulation in the sense that only those pressure pulses are transmitted whose energetic level is
25 higher than the current pressure in the high pressure exhaust channel. This allows to offset mainly the negative pressure pulses, i.e. the condition of quasi-negative pressure in the high pressure exhaust channel, and thus to raise the overall pressure level both in the high pressure
30 exhaust channel and in the high pressure charge air channel due to the smoothening of the negative pressure pulses. Consequently, the pressure level in the rotor prior to opening the high pressure channel is significantly raised,



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and the pulsations arriving from there are damped. Furthermore, this measure allows to reduce the admission losses of the hot exhaust gases in the rotor since the entire process is damped.

5

A further improvement is obtained if the bifurcation, which in FIG. 2 or 3 is located anywhere between the high pressure charge air channel edge and the motor inlet, is provided directly after the opening edge of the high pressure charge
10 air channel. This embodiment is not illustrated for the sake of clarity.

As previously mentioned, the pressure wave machine of the prior art is strongly dependent on the filling degree. In
15 addition to a reduction of the pressure pulsations, as described above, the presence of a connection allows the feedback of charge air to the high pressure exhaust side of the pressure wave machine and thus an increase of the mass flow of the machine and thereby an increase of the filling
20 degree, which results in a significant pressure increase. An additional regulation of the feedback amount of high pressure charge air by means of the regulated nonreturn valve may thus be used as a charging pressure regulation in general and additionally as a power regulation in the case
25 of a spark ignition engine.

In other words, this means that in order to improve the compression efficiency at higher motor flow rates, the pressure wave machine may be designed somewhat larger
30 without losing charging pressure at lower motor flow rates. This may also be obtained e.g. by regulating the cross-sectional area of the connecting channel by means of a suitable known device such as a controlled nonreturn valve



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or an additional device for the regulation of the cross-sectional area. This is especially effective in the lower to medium speed, temperature, and load range of the internal combustion engine.

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Claims

1. A gas-dynamic pressure wave machine which is destined for the charge air supply of an internal combustion engine, comprising a rotor (6, 40) with cells (18, 41), a low pressure fresh air inlet channel (14, 38), a high pressure charge air channel (10, 32) leading to the internal combustion engine (1, 33), a high pressure exhaust channel (3, 31) coming from the internal combustion engine, and a low pressure exhaust channel (4, 35), the low pressure exhaust channel (4, 35) and the high pressure exhaust channel (3, 31) being enclosed in a gas enclosure (5, 34) and the low pressure fresh air inlet channel (14, 38) and the high pressure charge air channel (10, 32) being enclosed in an air enclosure (15, 39), wherein **for eliminating detrimental motor pressure pulsations, increasing the filling degree and increasing the compression efficiency** a connection (46) is provided between the high pressure charge air channel (32) and the high pressure exhaust channel (31).
2. The gas-dynamic pressure wave machine of claim 1, wherein the connection (46) comprises a nonreturn valve (47) in order to prevent that exhaust gas may enter the charge air and in order to eliminate **said** detrimental pressure pulsations.
3. The gas-dynamic pressure wave machine of claim 2, wherein said nonreturn valve (47) is controlled by an electronic circuit.
4. The gas-dynamic pressure wave machine of any one of claims 1 to 3, wherein the cross-sectional area of the connection (46) is variable by means of a regulating device.



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5. The gas-dynamic pressure wave machine of any one of
claims 1 to 4, wherein the connection (46) bifurcates near
the opening edge of the high pressure charge air channel
5 (32).

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FIG. 1

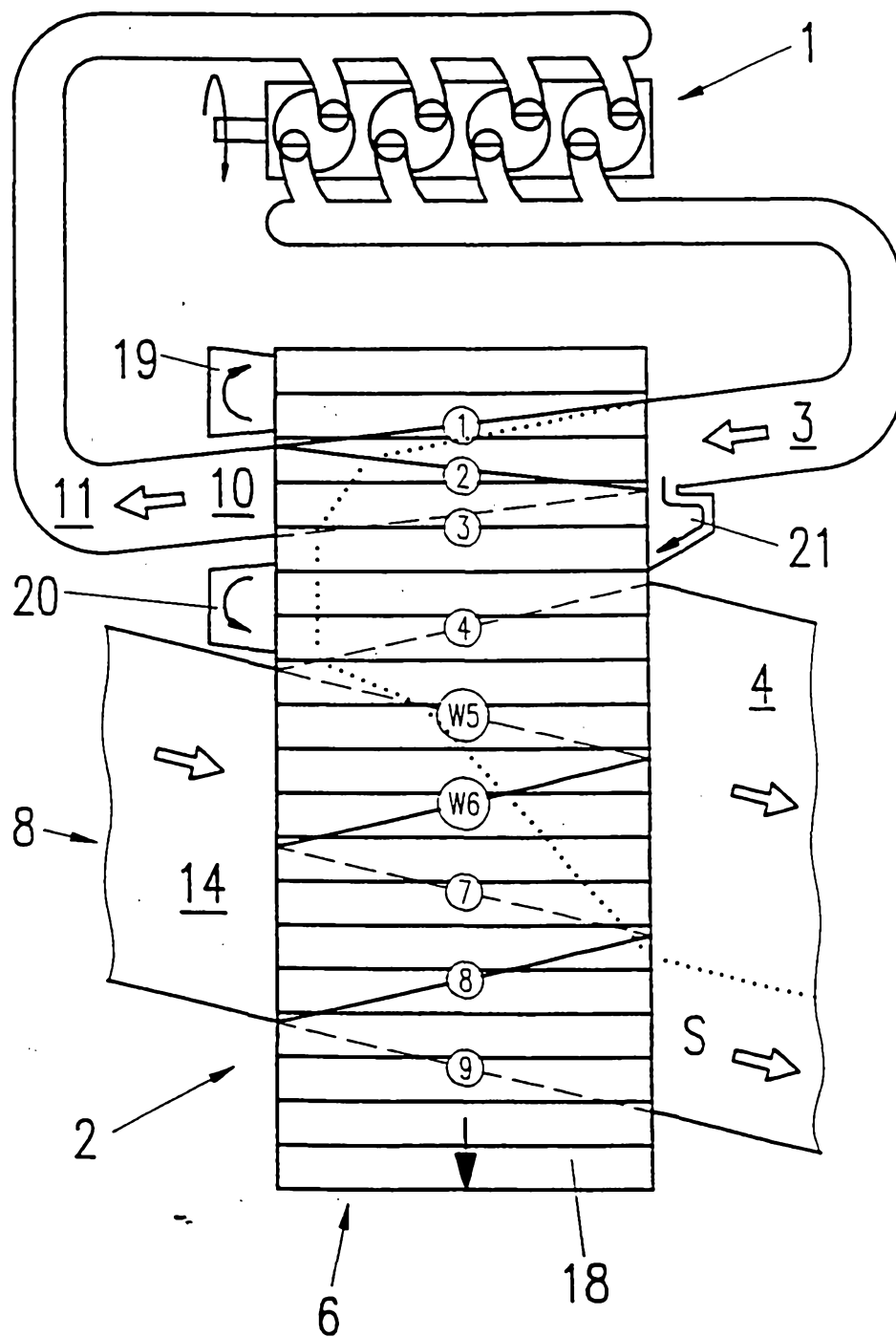


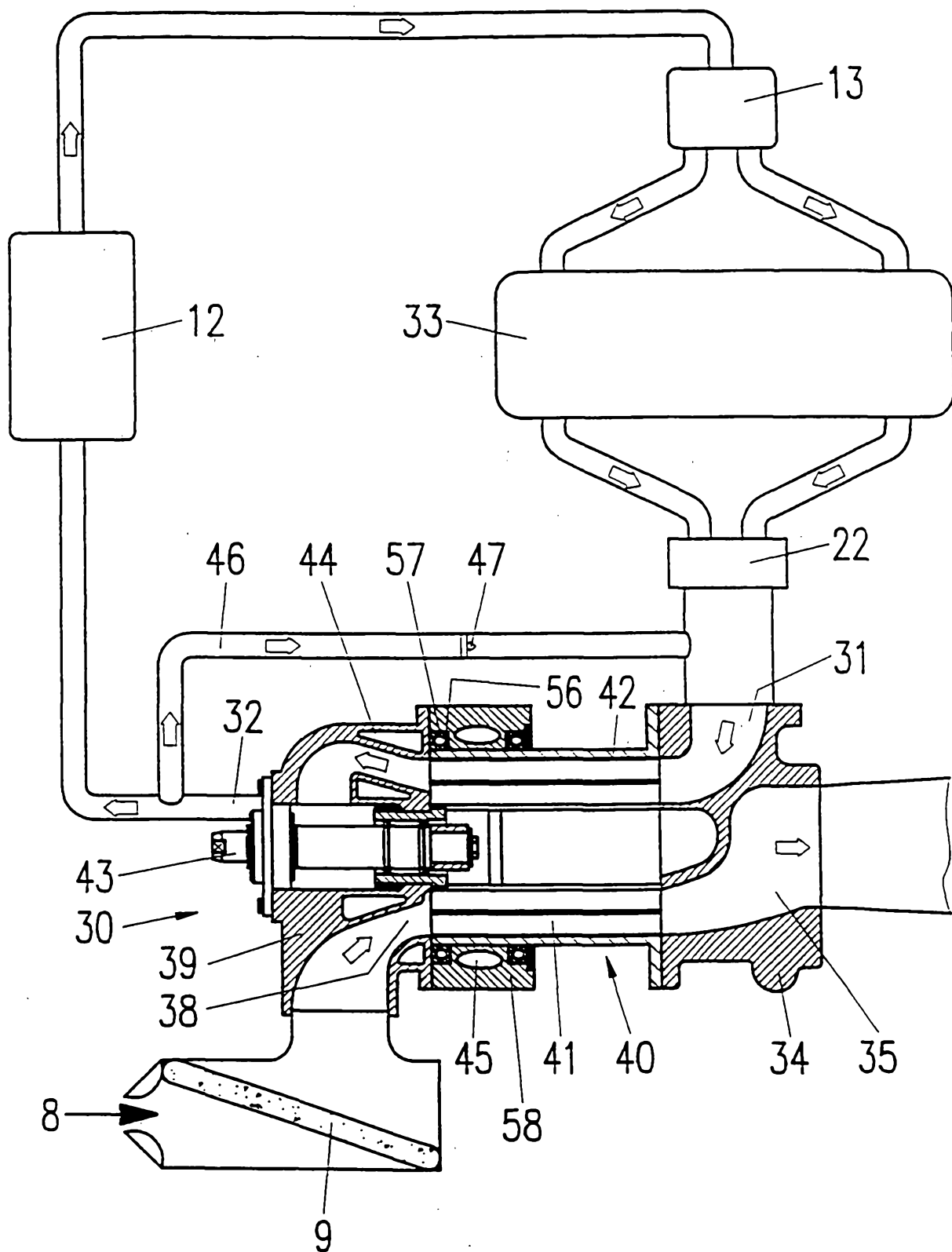
FIG. 2

FIG. 3

