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(54) ASSEMBLY FOR PRODUCING ELECTRIC POWER

ANORDNUNG ZUR ERZEUGUNG ELEKTRISCHER ENERGIE

ENSEMBLE DE PRODUCTION D'ÉNERGIE ÉLECTRIQUE

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(73) Proprietor: **Suisse Technology Group Sagl**
6900 Lugano (CH)

(72) Inventor: **BOTTI, Maurizio**
6900 Lugano (CH)

(74) Representative: **Brunacci, Marco**
BRUNACCI & PARTNERS S.r.l.
Via Pietro Giardini, 625
41125 Modena (MO) (IT)

(56) References cited:
WO-A1-03/091556
WO-A1-2007/059565
WO-A1-2011/006797
DE-A1- 4 344 915
US-A- 3 835 824
US-A- 4 480 599
US-A- 4 924 956

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Description

Technical Field

[0001] The present invention relates to an assembly for producing electric power.

[0002] More particularly, the present invention relates to an assembly for producing electric power intended for being installed in transport means (including road vehicles, boats, aircrafts), working means, lifting means, in order to increase the charge duration of the batteries, or, more generally, intended for being associated as a supporting unit with any equipment where the need to increase the charge duration of the accumulators is felt, or yet for being used in plants for electric power production by means of renewable sources, in order to increase the accumulation capacity of the batteries.

Prior Art

[0003] Electric power generating assemblies incorporating an internal combustion engine and exploiting therefore the high energy content of hydrocarbon fuels are known in the art.

[0004] US Patent No. 6 349 683 discloses a two-stroke or four-stroke internal combustion engine including a cylinder in which a combustion chamber is formed and a piston arranged to reciprocate within the cylinder. To this end, the piston is connected to a rod, and a helical spring has one end fastened to the cylinder and the opposite end fastened to the rod associated with the piston, whereby the piston moves (in the expansion step) against the spring resistance. The rod, at its distal end from the piston, carries an electrical induction coil that, by following the reciprocating motion of the piston, moves relative to a stationary permanent magnet, so as to generate electric power.

[0005] US Patent Application No. 2002/0139323 discloses an internal combustion engine including a pair of opposed pistons which are rigidly connected together by means of a common rod and are driven in an oscillatory movement. Said common rod carries a coil that, by following the oscillatory motion of the rod, moves relative to a stationary permanent magnet, so as to generate electric power.

[0006] Even if such prior art solutions enable obtaining electric power generation, they have a number of drawbacks.

[0007] More particularly, using a spring in order to brake the piston movement entails a number of complications, related in particular to fatigue stresses that can lead to the breakage of the spring itself and consequently of the engine.

[0008] Moreover, also the extension of the piston stroke and the attainable compression level are limited because of the presence of the spring, and this consequently limits the engine efficiency. Documents US 3835824A, US4924956A, and WO2011006797A disclose free piston engines having two pairs of pistons and having three combustion chambers, as in the current invention.

[0009] It is the main object of the present invention to overcome the drawbacks of the prior art solutions, by providing an electric power production assembly which is reliable, durable and efficient.

Brief Description of the Invention

[0010] The assembly for producing electric power according to the invention includes a housing in which a first substantially cylindrical portion is formed, inside which a first combustion chamber is formed and a first piston is arranged to reciprocate. Moreover, a second substantially cylindrical portion is formed inside said housing, a second combustion chamber being formed inside the second portion and a second piston being arranged to reciprocate within the second portion. The first piston is connected to a first end of a first rod, which carries at its opposed second end a third piston. The second piston is connected to a first end of a second rod, which carries at its opposed second end a fourth piston. The third and fourth pistons define, together with the housing walls, a third combustion chamber, which is therefore located between said third and fourth pistons and within which said third and fourth pistons are arranged to reciprocate.

[0011] The combustion chambers can have any displacement and can be water-cooled or air cooled.

[0012] Preferably, the first and second rods are coaxial, so that the third combustion chamber has a substantially cylindrical shape and the housing of the assembly according to the invention has a substantially cylindrical shape.

[0013] The first rod is rigidly connected, by means of one or more first supports, to a set of first coils / first permanent magnets that, by following the reciprocating motion of the first and third pistons, move relative to a set of stationary first permanent magnets / stationary first coils, so as to generate electric power. The second rod is rigidly connected, by means of one or more second supports, to a set of second coils / second permanent magnets that, by following the reciprocating motion of the second and fourth pistons, move relative to a set of stationary second permanent magnets / stationary second coils, so as to generate electric power.

[0014] Advantageously, in the assembly for producing electric power according to the invention, the movement of each piston is braked not only by the electric power generation but also by the compression of the piston located at the opposed end of the respective rod.

[0015] Consequently, the invention allows overcoming the limitations of the prior art solutions, imposed by the provision of springs or other elastically resistant means.

[0016] Moreover, in every forth and back cycle of each piston, two ignitions occur instead of one, and this allows considerably increasing the performance of the assem-

bly according to the invention and the power supplied by it.

[0017] Moreover, with respect to a configuration including two opposed free pistons, the solution according to the invention allows significantly reducing vibrations, since it comprises equal oscillating masses moving in opposition.

[0018] At the same time, with respect to a configuration including two opposed free pistons, the solution according to the invention allows reducing the displacement of the individual pistons, and consequently the overall size, for a given amount of electric power produced.

[0019] Advantageously, in every forth and back cycle, the provision of said third combustion chamber, common to the third and fourth pistons, allows synchronising the system, i.e. the reciprocating movement of the first and second rods and of the elements connected thereto.

[0020] Advantageously, the assembly for producing electric power according to the invention can be manufactured by using standard, commercially available components, and this ensures reliability and limited prices.

Brief Description of the Figures

[0021] Further features and advantages of the present invention will become more apparent from the detailed description of a preferred embodiment thereof, given by way of nonlimiting example with reference to the accompanying drawings, in which:

- Fig. 1a schematically shows a longitudinal sectional view of an assembly for producing electric power according to a preferred embodiment of the present invention, in a first operating position;
- Fig. 1b schematically shows a longitudinal sectional view of the assembly for producing electric power shown in Fig. 1a, in a second operating position;
- Fig. 1c schematically shows a longitudinal sectional view of the assembly for producing electric power shown in Fig. 1a, in a third operating position;
- Fig. 1d schematically shows a longitudinal sectional view of the assembly for producing electric power shown in Fig. la, in a fourth operating position.

[0022] For the sake of clarity, in Figs. 1a to 1d the portion of the assembly for producing electric power according to the invention at the right hand side of the drawings, i.e. the portion included between the third combustion chamber and the second combustion chamber, is fictitiously rotated by 90° relative to its actual arrangement.

Description of a Preferred Embodiment

[0023] Referring to Figs. 1a to 1d, there is shown the assembly for producing electric power according to the invention, denoted in the whole by reference numeral 1.

[0024] Assembly 1 includes a housing 3 at a first end of which a first substantially cylindrical portion 3a is formed, housing a first combustion chamber 5a.

[0025] In a manner known per se, the first combustion chamber 5a has a substantially cylindrical shape and is equipped with fuel injection means (not shown) and with ignition means 7a for fuel ignition. Moreover, the first combustion chamber 5a is equipped with an inlet port 8a in communication with an inlet duct 9a for introducing air into the first combustion chamber. Said inlet duct 9a is in communication with an intake duct 11a equipped with an intake valve 10a, and opens into the first combustion chamber or, preferably, into a pre-compression chamber connected thereto, as it will be described in detail hereinafter. The first combustion chamber 5a is also equipped with an outlet port 12a in communication with an exhaust duct 13a for the outflow of exhaust gases from the first combustion chamber.

[0026] A first piston 15a is mounted free inside the first portion 3a of housing 3 and delimits the first combustion chamber 5a. The first piston 15a is housed in said first portion 3a of housing 3 so as to be able to reciprocate within it.

[0027] At a second end, opposed to the first end, housing 3 has a second substantially cylindrical portion 3b, housing a second combustion chamber 5b.

[0028] In a manner known per se, the second combustion chamber 5b has a substantially cylindrical shape and is equipped with fuel injection means (not shown) and with ignition means 7b for fuel ignition. Moreover, the second combustion chamber 5b is equipped with an inlet port 8b in communication with an inlet duct 9b for introducing air into the second combustion chamber. Said inlet duct 9b is in communication with an intake duct 11b equipped with an intake valve 10b, and opens into the second combustion chamber or, preferably, into a pre-compression chamber connected thereto, as it will be described in detail hereinafter. The second combustion chamber 5b is also equipped with an outlet port 12b in communication with an exhaust duct 13b for the outflow of exhaust gases from the second combustion chamber.

[0029] A second piston 15b is mounted free inside the second portion 3b of housing 3 and delimits the second combustion chamber 5b. The second piston 15b is housed in said second portion 3b of housing 3 so as to be able to reciprocate within it.

[0030] According to the invention, the first piston 15a is connected to a first end of a first rod 17a, which carries at its opposed end a third piston 15c, and the second piston 15b is connected to a first end of a second rod 17b, which carries at its opposed end a fourth piston 15d.

[0031] The third piston 15c and the fourth piston 15d define, together with the walls of housing 3, a third combustion chamber 5c, which is formed in an intermediate, substantially central portion 3c of said housing 3.

[0032] Also the third combustion chamber 5c is equipped with fuel injection means (not shown) and with ignition means 7c for fuel ignition. Moreover, the third combustion chamber 5c is equipped with two inlet ports 8c, 8d in communication with respective inlet ducts 9c,

9d for introducing air into the third combustion chamber. A first inlet duct 9c is in communication with intake duct 11a of the first combustion chamber 5a through an intake valve 10c and opens into the second combustion chamber or, preferably, into a pre-compression chamber connected thereto, as it will be described in detail hereinafter. A second inlet duct 9d is in communication with intake duct 11b of the second combustion chamber 5b through an intake valve 10d and opens into the third combustion chamber or, preferably, into a pre-compression chamber connected thereto, as it will be described in detail hereinafter. The third combustion chamber 5c is also equipped with two outlet ports 12c, 12d in communication with exhaust duct 13a of the first combustion chamber and exhaust duct 13b of the second combustion chamber, respectively, for the outflow of exhaust gases from the third combustion chamber.

[0033] Preferably, as shown in the drawings, rods 17a, 17b are coaxially arranged, so that also the third combustion chamber 5c has a substantially cylindrical shape and housing 3 of assembly 1 has in the whole a substantially cylindrical shape.

[0034] Preferably, in order to obtain a proper operation in steady state condition and to minimise vibrations, the first and second rods 17a, 17b have the same mass and the same size, the first and second pistons 15a, 15b have the same mass and the same size, and the third and fourth pistons 15c, 15d have the same mass and the same size. More preferably, all pistons 15a - 15d have the same mass and the same size.

[0035] Advantageously, in the illustrated embodiment, the first rod 17a is mounted on longitudinal bearings 19a, 19c (or similar components) suitably arranged so as to define a first space 21a which is located between the first piston 15a and one of said bearings (bearing 17a) and is in communication with supply duct 11a and inlet duct 9a of the first combustion chamber, and a second space 21 which is located between the first piston 15a and the other one 17c of said bearings and is in communication with supply duct 1 1a and inlet duct 9c of the third combustion chamber. As stated before, said spaces 21a, 21c can be advantageously exploited as pre-compression chambers for a first compression of air coming from supply duct 11a before such air enters inlet duct 9a of the first combustion chamber or inlet duct 9c of the third combustion chamber, as it will be disclosed hereinafter.

[0036] Similarly, in the illustrated embodiment, the second rod 17b is mounted on longitudinal bearings 19b, 19d (or similar components) suitably arranged so as to define a first space 21b which is located between the second piston 15b and one of said bearings (bearing 17b) and is in communication with supply duct 11b and inlet duct 9b of the second combustion chamber, and a second space 21d which is located between the fourth piston 15d and the other one 17d of said bearings and is in communication with supply duct 11b and inlet duct 9d of the third combustion chamber. As stated before, said spaces 21b, 21d can be advantageously exploited as pre-compression chambers for a first compression of air coming from supply duct 11b before such air enters inlet duct 9b of the second combustion chamber or inlet duct 9d of the third combustion chamber, as it will be disclosed hereinafter.

[0037] According to the invention, one or more first supports 23a are fastened to the first rod 17a, preferably in an intermediate position between the first piston 15a and the third piston 15c. Those supports carry sets of first magnets 25a facing sets of first induction coils 27a, so that, when the first piston 15a reciprocates within the first portion 3a of housing 3, the first magnets 25a reciprocate relative to the first coils 27a.

[0038] Preferably, two first supports 23a (only one of which is shown in Figs. 1a to 1d) are fastened to the first rod 17a. Said supports are arranged at 180° relative to each other and each of them carries a respective set of first magnets 25a, facing a respective set of first induction coils 27a.

[0039] It will be apparent to the skilled in the art that, in an alternative embodiment of the invention, the first supports 23a could carry the induction coils and the magnets could be stationary and arranged so as to face the paths of said coils.

[0040] However, a configuration in which the first coils 27a are stationary and the first magnets 26a are fixedly connected to the first rod 17a is deemed preferable, especially taking into account the reduced weight of the magnets with respect to the coils.

[0041] Always in accordance with the invention, one or more second supports 23b are fastened to the second rod 17b, preferably in an intermediate position between the second piston 15b and the fourth piston 15d. Those supports carry sets of second magnets 25b facing sets of second induction coils 27b, so that, when the second piston 15b reciprocates within the second portion 3b of housing 3, the second magnets 25b reciprocate relative to the second coils 27b.

[0042] Preferably, two second supports 23b (only one of which is shown in Figs. 1a to 1d) are fastened to the second rod 17b. Said supports are arranged at 180° relative to each other and each of them carries a respective set of second magnets 25b, facing a respective set of second induction coils 27b.

[0043] Preferably, the second supports 23b are offset by 90° relative to the first supports 23a.

[0044] It will be apparent to the skilled in the art that, in an alternative embodiment of the invention, the second supports 23b could carry the induction coils and the magnets could be stationary and arranged so as to face the path of said coils.

[0045] However, a configuration in which the second coils 27b are stationary and the second magnets 26b are fixedly connected to the second rod 17b is deemed preferable, especially taking into account the reduced weight of the magnets with respect to the coils.

[0046] Therefore, in the illustrated embodiment, assembly 1 for producing electric power according to the

invention comprises in the whole four sets of magnets (two sets of first magnets 25a and two sets of second magnets 25b) and four sets of respective coils (two sets of first coils 27 a and two sets of second coils 27b) arranged in a cross-shaped pattern.

[0047] Respective pumps for fuel injection and small pumps for lubricating oil can moreover be fastened to the first rod 17a as well as to the second rod 17b.

[0048] Preferably, supports 23a, 23b, as well as the elements associated therewith and further components, if any, mounted on rods 17a, 17b, have the same mass and the same size, so as to maintain the overall symmetry of assembly 1 for producing electric power.

[0049] The operation of assembly 1 for producing electric power according to the invention can be summarised as follows.

[0050] All pistons 15a - 15d operate according to the principle of a two-stroke engine.

[0051] In a first step, shown in Fig 1a, the third and fourth pistons 15c, 15d are at their minimum relative distance and compress the air-fuel mixture present in the third combustion chamber 5c. Conversely, the first and second combustion chambers 5a, 5b are in communication with the respective inlet ducts 9a, 9b and exhaust ducts 13a, 13b through the respective inlet ports 8a, 8b and outlet ports 12a, 12b.

[0052] The air-fuel mixture present in the third combustion chamber 5c is therefore ignited and ignition occurs, as a consequence of which the third and fourth pistons 15c, 15d are moved away from each other. Consequently, the first piston 15a moves towards the end of the first portion 3a of housing 3 and covers inlet port 8a and outlet port 12a. At this point, fuel is injected into the first combustion chamber and the first piston 15a starts compressing the air-fuel mixture present in said first combustion chamber 5a. At the same time, the second piston 15b moves towards the end of the second portion 3b of housing 3 and covers inlet port 8b and outlet port 12b. At this point, fuel is injected into the second combustion chamber and the second piston 15b starts compressing the air-fuel mixture present in the second combustion chamber 5b. In the meanwhile, the third and fourth pistons 15c, 15d, during their movement away from each other, cause a first compression of air present in pre-compression chambers 21c, 21d. This step is shown in Fig. 1b.

[0053] Fig. 1c shows the step in which the distance between the first piston 15a and the end of the first portion 3a of housing 3 is minimum, as is the distance between the second piston 15b and the end of the second portion 3b of housing 3. In the meanwhile, the third piston 15c and the fourth piston 15d, continuing their movement away from each other, have left respective outlet ports 12c, 12d of the third combustion chamber uncovered, thereby allowing outflow of exhaust gases into respective exhaust ducts 13c, 13d. At the same time, the third piston 15c and the fourth piston 15d have left respective inlet ports 8c, 8d of the third combustion chamber uncovered, thereby allowing substitution of the exhaust gases discharged with pre-compressed fresh air coming from respective inlet ducts 9c, 9d.

[0054] In the configuration shown in Fig. 1c, the air-fuel mixture present in the first combustion chamber 5a is ignited, as is the air-fuel mixture present in the second combustion chamber 5b. Consequently ignition occurs in both said combustion chambers, as a consequence of which the first piston 15a is moved away from the end of the first portion 3a of housing 3 and the second piston 15b is moved away from the end of the second portion 3b of housing 3. In this manner, they cause a first compression of air contained in pre-compression chambers 21a, 21b, respectively. Moreover, the third piston 15c and the fourth piston 15d start moving towards each other, so as to cover again inlet ports 8c, 8d and outlet ports 12c, 12d of the third combustion chamber 5c. At this point, fuel can be introduced into the third combustion chamber 5c and the third piston 15c and the fourth piston 15d, continuing their movement towards each other, compress the air-fuel mixture present in said third combustion chamber 5c. This step is shown in Fig. 1d.

[0055] By continuing the movement of the third and fourth pistons 15c, 15d towards each other until attaining the maximum compression, the configuration shown in Fig. 1a is resumed and the cycle is over. It will be appreciated that, in Fig. 1a, the first piston 15a has moved away from the end of the first portion 3a of housing 3 sufficiently to uncover inlet port 8a and outlet port 12a, thereby allowing the outflow of exhaust gases into exhaust duct 13a and the substitution of said exhaust gases with pre-compressed fresh air coming from inlet duct 9a. In a wholly similar manner, the second piston 15b has moved away from the end of the second portion 3b of housing 3 sufficiently to uncover inlet port 8b and outlet port 12b, thereby allowing the outflow of exhaust gases into exhaust duct 13b and the substitution of said exhaust gases with pre-compressed fresh air coming from inlet duct 9b.

[0056] As it is clearly apparent from Figs. 1a - 1d, the cycle described above results in a reciprocating linear motion of the first rod 17a and the second rod 17b.

[0057] Consequently, the sets of first and second magnets 25a, 25b move of reciprocating linear motion relative to the sets of stationary first coils 27a and second coils 27b, respectively, thereby generating an electric current.

[0058] Advantageously, during the reciprocating linear motion, in every forth and back cycle of the first rod 17a, two ignitions occur instead of one, namely, one ignition in the first combustion chamber 5a and the other in the third combustion chamber 5c. Similarly, in every forth and back cycle of the second rod 17b, two ignitions occur instead of one, namely, one ignition in the second combustion chamber 5b and the other in the third combustion chamber 5c. Consequently, the efficiency of assembly 1 according to the invention and the amount of electric power generated by it are particularly high.

[0059] Moreover, advantageously, the compressions

in combustion chambers 5a, 5c located at the opposed sides of the first rod 17a determine, jointly with the production of electric power by the first magnets 25a and the first coils 27a, the braking effect on said first rod 17a, and the compressions in combustion chambers 5b, 5c located at the opposed sides of the second rod 17b determine, jointly with the production of electric power by the second magnets 25b and the second coils 27b, the braking effect on said second rod 17b: it is the compressions in the combustion chambers located at the opposed sides of each rod that oppose the inertia of each rod, which is free.

[0060] It is to be appreciated that, at the start, electric generation units consisting of the sets of magnets 25a, 25b and the sets of coils 27a, 27b can be advantageously exploited to start the cycle of compressions and expansions in the various combustion chambers 5a - 5c. More particularly, coils 27a, 27b can be excited so as to bring the third and fourth pistons 15c, 15d to the position of maximum mutual distance, so as to allow filling the third combustion chamber 5c. Subsequently, always thanks to the coil excitation, the third and fourth pistons 15c, 15d can be moved towards each other so as to compress the air-fuel mixture present in said third combustion chamber. At this point, the mixture is ignited by ignition means 7c and the start takes place.

[0061] In steady state condition, the frequency of the reciprocating linear motion of rods 17a, 17b and of the pistons associated therewith can be adjusted so as to minimise fuel consumption.

[0062] Said steady state condition should be constant, without accelerations or decelerations and without modifications in the load of the electric generation units consisting of the sets of magnets 25a, 25b and the sets of coils 27a, 27b.

[0063] Thanks to the fact that the ignition in the third combustion chamber 5c acts in the same way on the third and fourth pistons 15c, 15d, the system is continuously calibrated and the movements of both rods 17a, 17b are identical (in opposed directions) and synchronous.

[0064] This not only ensures a stationary regime, but also allows avoiding vibrations, since equal oscillating masses moving in opposition are obtained.

[0065] Assembly 1 disclosed above may use, as fuel, any liquid or gaseous fuel available in the market (including gasoline, naphtha, kerosene, liquefied petroleum gas, methane and natural gas).

[0066] Even if the Figures schematically show a direct injection system, it will be apparent for the skilled in the art that an indirect injection system or a system with conventional suction of a liquid or gaseous fuel can be used.

[0067] The individual components can be cooled either with air (by means of natural or forced circulation), or with water or other cooling liquids.

[0068] The above description clearly makes it apparent that the assembly for producing electric power according to the invention is reliable, robust and efficient, and thus it allows wholly achieving the objects set forth above.

[0069] Moreover, the assembly advantageously comprises a reduced number of components.

[0070] Further, it will be understood that the embodiment described here in detail has been given only by way of example and that several changes and modifications in the reach of the skilled in the art are possible, without thereby departing from the scope of the invention as defined in the appended claims.

[0071] In particular, even if in the illustrated embodiment each rod carries two supports arranged at 180° relative to each other, it is also possible to provide rods carrying each a different number of supports: e.g., four supports arranged at 90° relative to one another could be associated with each rod.

[0072] Moreover, even if in the illustrated embodiment the pistons operate according to the principle of a two-stroke engine, it is also possible to provide that said pistons operate according to the principle of a four-stroke engine.

Claims

1. An assembly (1) for producing electric power, including a housing (3) at a first end of which a first substantially cylindrical portion (3a) housing a first combustion chamber (5a) is formed, and at a second end of which a second substantially cylindrical portion (3b) housing a second combustion chamber (5b) is formed, wherein a first piston (15a) is housed within said first portion (3a) of said housing (3) and delimits said first combustion chamber (5a), said first piston (15a) being housed free within said first portion of said housing and being arranged to reciprocate therein, and wherein a second piston (15b) is housed within said second portion (3b) of said housing (3) and delimits said second combustion chamber (5b), said second piston (15b) being housed free within said second portion of said housing and being arranged to reciprocate therein, said first piston (15a) being connected to a first end of a first rod (17a) carrying at its opposed end a third piston (15c) and said second piston (15b) is connected to a first end of a second rod (17b), carrying at its opposed end a fourth piston (15d), said third piston (15c) and said fourth piston (15d) defining, together with the walls of said housing, a third combustion chamber (5c) formed in an intermediate portion (3c) of said housing,

said first rod (17a) has fastened thereto one or more first supports (23a) carrying sets of first magnets (25a) or first induction coils (27a), facing sets of stationary first induction coils (27a) or stationary first magnets, and said second rod (17b) has fastened thereto one or more second supports (23b) carrying sets of second magnets (25b) or second induction coils (27b) which face sets of stationary second induction coils (27b) or stationary second magnets,

characterized in that said first combustion chamber (5a):
is equipped with fuel injection means and with ignition means (7a) for fuel ignition; is also equipped with an inlet port (8a) in communication with an inlet duct (9a) for introducing air into said first combustion chamber, said inlet duct (9a) being in communication with an intake duct (11 a) equipped with an intake valve (10a); and
is also equipped with an outlet port (12a) in communication with an exhaust duct (13a) for the outflow of exhaust gases from said first combustion chamber (5a);
and wherein said second combustion chamber (5b):

is equipped with fuel injection means and with ignition means (7b) for fuel ignition;
is also equipped with an inlet port (8b) in communication with an inlet duct (9b) for introducing air into said second combustion chamber, said inlet duct (9b) being in communication with an intake duct (11b) equipped with an intake valve (10b); and
is further equipped with an outlet port (12b) in communication with an exhaust duct (13b) for the outflow of exhaust gases from said second combustion chamber (5b),
wherein said third combustion chamber (5c):

is equipped with fuel injection means and with ignition means (7c) for fuel ignition;
is also equipped with two inlet ports (8c, 8d) in communication with respective inlet ducts (9c, 9d) for introducing air into said third combustion chamber, one (9c) of said inlet ducts being in communication with said intake duct (11a) of said first combustion chamber (5a) through an intake valve (10c), and the other (9d) of said inlet ducts being in communication with said intake duct (11b) of said second combustion chamber (5b) through an intake valve (10d); and
is further equipped with two outlet ports (12c, 12d) in communication with said exhaust duct (13a) of said first combustion chamber and with said exhaust duct (13b) of said second combustion chamber, respectively, for the outflow of exhaust gases from said third combustion chamber.

2. The assembly (1) as claimed in claim 1, wherein said first rod (17a) and said second rod (17b) are coaxially arranged, so that said third combustion chamber (5c) has a substantially cylindrical shape.

3. The assembly (1) as claimed in claim 1 or 2, wherein said first rod (17a) and said second rod (17b) have the same size and mass, wherein said first and second pistons (15a, 15b) have the same size and mass and wherein said third and fourth pistons (15c, 15d) have the same size and mass.

4. The assembly (1) as claimed in claim 3, wherein said first and second pistons (15a, 15b) have the same size and mass as said third and fourth pistons (15c, 15d).

5. The assembly (1) as claimed in any of claims 1 to 4, wherein two first supports (23a) arranged at 180° relative to each other are fastened to said first rod (17a).

6. The assembly (1) as claimed in any of claims 1 to 4, wherein two second supports (23b) arranged at 180° relative to each other are fastened to said second rod (17b) .

7. The assembly (1) as claimed in any of claims 1 to 4, wherein two first supports (23a) arranged at 180° relative to each other are fastened to said first rod (17a), wherein two second supports (23b) arranged at 180° relative to each other are fastened to said second rod (17b), and wherein said second supports (23b) are offset by 90° relative to said first supports (23a).

8. The assembly (1) as claimed in any of claims 1 to 4, wherein four first supports arranged at 90° relative to each other are fastened to said first rod (17a), and wherein four second supports arranged at 90° relative to each other are fastened to said second rod (17b).

9. The assembly (1) as claimed in any of claims 1 to 8, wherein said first rod (17a) is mounted on longitudinal bearings (19a, 19c) defining a first space (21 a) which is located between the first piston (15a) and one (17a) of said bearings and is in communication with said supply duct (11a) of said first combustion chamber and said inlet duct (9a) of said first combustion chamber, and a second space (21 c) which is located between said third piston (15a) and the other one (17c) of said bearings and is in communication with said supply duct (11a) of said first combustion chamber and said inlet duct (9c) of said third combustion chamber, and wherein said second rod (17b) is mounted on longitudinal bearings (19b, 19d) defining a first space (21 b) which is located between the second piston (15b) and one (17b) of said bearings and is in communication with said supply duct (11b) of said second combustion chamber and said inlet duct (9b) of said second combustion chamber, and a second space (21d) which is located between said fourth piston (15d) and the other one (17d) of said bearings and is in communication with said supply duct (11b) and said inlet duct (9d) of said third

combustion chamber.

Patentansprüche

1. Anordnung (1) zur Erzeugung elektrischer Energie, mit einem Gehäuse (3), an dessen ersten Ende ein erster, im wesentlichen zylindrischer Abschnitt (3a) ausgebildet ist, der eine erste Verbrennungskammer (5a) aufnimmt, und an dessen zweitem Ende ein zweiter, im wesentlichen zylindrischer Abschnitt (3b) ausgebildet ist, der eine zweite Verbrennungskammer (5b) aufnimmt, wobei ein erster Kolben (15a) innerhalb des ersten Abschnitts (3a) des Gehäuses (3) untergebracht ist und die erste Verbrennungskammer (5a) begrenzt, wobei der erste Kolben (15a) frei innerhalb des ersten Abschnitts des Gehäuses untergebracht ist und so angeordnet ist, dass er sich darin hin- und herbewegt und wobei ein zweiter Kolben (15b) innerhalb des zweiten Abschnitts (3b) des Gehäuses (3) untergebracht ist und die zweite Verbrennungskammer (5b) begrenzt, wobei der zweite Kolben (15b) frei innerhalb des zweiten Abschnitts des Gehäuses untergebracht und so angeordnet ist, dass er sich darin hin- und herbewegt, der erste Kolben (15a) mit einem ersten Ende einer ersten Stange (17a) verbunden ist, die an ihrem gegenüberliegenden Ende einen dritten Kolben (15c) trägt, und der zweite Kolben (15b) mit einem ersten Ende einer zweiten Stange (17b) verbunden ist, die an ihrem gegenüberliegenden Ende einen vierten Kolben (15d) trägt, wobei der dritte Kolben (15c) und der vierte Kolben (15d) zusammen mit den Wänden des Gehäuses eine dritte Verbrennungskammer (5c) bilden, die in einem Zwischenabschnitt (3c) des Gehäuses ausgebildet ist,

   die erste Stange (17a) einen oder mehrere daran befestigte erste Träger (23a) aufweist, die Sätze von ersten Magneten (25a) oder ersten Induktionsspulen (27a) tragen, die Sätzen von stationären ersten Induktionsspulen (27a) oder stationären ersten Magneten zugewandt sind, und die zweite Stange (17b) einen oder mehrere daran befestigte zweite Träger (23b) aufweist, die Sätze von zweiten Magneten (25b) oder zweiten Induktionsspulen (27b) tragen, die Sätzen von stationären zweiten Induktionsspulen (27b) oder stationären zweiten Magneten zugewandt sind,
   dadurch gekennzeichnet, dass die erste Verbrennungskammer (5a):

      mit Kraftstoffeinspritzungsmitteln und mit Zündmitteln (7a) zur Zündung des Kraftstoffs ausgestattet ist;
      zudem mit einer Einlassöffnung (8a) ausgestattet ist, die mit einem Einlasskanal (9a) zum Einführen von Luft in die erste Verbrennungskammer in Verbindung steht, wobei der Einlasskanal (9a) mit einem Zufuhrkanal (11a) in Verbindung steht, der mit einem Zufuhrventil (10a) ausgestattet ist; und
      ferner mit einer Auslassöffnung (12a) ausgestattet ist, die mit einer Abgasleitung (13a) für den Ausfluss von Abgasen aus der ersten Verbrennungskammer (5a) in Verbindung steht; und

   wobei die zweite Verbrennungskammer (5b):

      mit Kraftstoffeinspritzungsmitteln und mit Zündmitteln (7b) zur Zündung des Kraftstoffs ausgestattet ist;
      zudem mit einer Einlassöffnung (8b) ausgestattet ist, die mit einem Einlasskanal (9b) zum Einleiten von Luft in die zweite Verbrennungskammer in Verbindung steht, wobei der Einlasskanal (9b) mit einem Zufuhrkanal (11b) in Verbindung steht, der mit einem Zufuhrventil (10b) ausgestattet ist; und
      ferner mit einer Auslassöffnung (12b) ausgestattet ist, die mit einer Abgasleitung (13b) für das Ausströmen von Abgasen aus der zweiten Verbrennungskammer (5b) in Verbindung steht, und

   wobei die dritte Verbrennungskammer (5c):

      mit Kraftstoffeinspritzungsmitteln und mit Zündmitteln (7c) zur Zündung von Kraftstoff ausgestattet ist;
      zudem mit zwei Einlassöffnungen (8c, 8d) ausgestattet ist, die mit jeweiligen Einlasskanälen (9c, 9d) in Verbindung stehen, um Luft in die dritte Verbrennungskammer einzuleiten, wobei einer der Einlasskanäle (9c) mit dem Zufuhrkanal (11a) der ersten Verbrennungskammer (5a) über ein Zufuhrventil (10c) in Verbindung steht und der andere der Einlasskanäle (9d) mit dem Zufuhrkanal (11b) der zweiten Verbrennungskammer (5b) über ein Zufuhrventil (10d) in Verbindung steht; und
      ferner mit zwei Auslassöffnungen (12c, 12d) ausgestattet ist, die mit der Abgasleitung (13a) der ersten Verbrennungskammer bzw. mit der Abgasleitung (13b) der zweiten Verbrennungskammer für das Ausströmen von Abgasen aus der dritten Verbrennungskammer in Verbindung stehen.

2. Anordnung (1) nach Anspruch 1, wobei die erste Stange (17a) und die zweite Stange (17b) koaxial angeordnet sind, so dass die dritte Verbrennungs-

kammer (5c) eine im Wesentlichen zylindrische Form aufweist.

3. Anordnung (1) nach Anspruch 1 oder 2, wobei die erste Stange (17a) und die zweite Stange (17b) die gleiche Größe und Masse haben, wobei der erste und zweite Kolben (15a, 15b) die gleiche Größe und Masse haben und wobei der dritte und vierte Kolben (15c, 15d) die gleiche Größe und Masse haben.

4. Anordnung (1) nach Anspruch 3, wobei der erste und zweite Kolben (15a, 15b) die gleiche Größe und Masse wie der dritte und vierte Kolben (15c, 15d) haben.

5. Anordnung (1) nach einem der Ansprüche 1 bis 4, wobei an der ersten Stange (17a) zwei unter 180° zueinander angeordnete erste Träger (23a) befestigt sind.

6. Anordnung (1) nach einem der Ansprüche 1 bis 4, wobei an der zweiten Stange (17b) zwei unter 180° zueinander angeordnete zweite Träger (23b) befestigt sind.

7. Anordnung (1) nach einem der Ansprüche 1 bis 4, wobei an der ersten Stange (17a) zwei um 180° zueinander angeordnete erste Träger (23a) befestigt sind, wobei an der zweiten Stange (17b) zwei um 180° zueinander angeordnete zweite Träger (23b) befestigt sind, und wobei die zweiten Träger (23b) um 90° zu den ersten Trägern (23a) versetzt sind.

8. Anordnung (1) nach einem der Ansprüche 1 bis 4, wobei an der ersten Stange (17a) vier um 90° zueinander angeordnete erste Träger befestigt sind, und wobei an der zweiten Stange (17b) vier um 90° zueinander angeordnete zweite Träger befestigt sind.

9. Anordnung (1) nach einem der Ansprüche 1 bis 8, wobei die erste Stange (17a) auf Längslagern (19a, 19c) montiert ist, die einen ersten Raum (21a) definieren, der sich zwischen dem ersten Kolben (15a) und einem (17a) der Lager befindet und mit dem Zufuhrkanal (11a) der ersten Verbrennungskammer und dem Einlasskanal (9a) der ersten Verbrennungskammer in Verbindung steht, und einen zweiten Raum (21c), der sich zwischen dem dritten Kolben (15a) und dem anderen (17c) der Lager befindet und mit dem Zufuhrkanal (11a) der ersten Verbrennungskammer und dem Einlasskanal (9c) der dritten Verbrennungskammer in Verbindung steht, und wobei die zweite Stange (17b) auf Längslagern (19b, 19d) montiert ist, die einen ersten Raum (21b) definieren, der sich zwischen dem zweiten Kolben (15b) und einem (17b) der Lager befindet und mit dem Zufuhrkanal (11b) der zweiten Verbrennungskammer und dem Einlasskanal (9b) der zweiten Verbrennungskammer in Verbindung steht, und einen zweiten Raum (21d), der sich zwischen dem vierten Kolben (15d) und dem anderen (17d) der Lager befindet und mit dem Zufuhrkanal (11b) und dem Einlasskanal (9d) der dritten Verbrennungskammer in Verbindung steht.

Revendications

1. Ensemble (1) de production d'énergie électrique, comportant un boîtier (3) à une première extrémité duquel est formée une première partie sensiblement cylindrique (3a) logeant une première chambre de combustion (5a), et à une deuxième extrémité duquel est formée une deuxième partie sensiblement cylindrique (3b) logeant une deuxième chambre de combustion (5b), dans lequel un premier piston (15a) est logé à l'intérieur de ladite première partie (3a) dudit boîtier (3) et délimite ladite première chambre de combustion (5a), ledit premier piston (15a) étant logé librement à l'intérieur de ladite première partie dudit boîtier et étant agencé pour effectuer un mouvement alternatif dans celle-ci, et dans lequel un deuxième piston (15b) est logé à l'intérieur de ladite deuxième partie (3b) dudit boîtier (3) et délimite ladite deuxième chambre de combustion (5b), ledit deuxième piston (15b) étant logé librement à l'intérieur de ladite deuxième partie dudit boîtier et étant agencé pour effectuer un mouvement alternatif dans celle-ci, ledit premier piston (15a) étant relié à une première extrémité d'une première tige (17a) portant à son extrémité opposée un troisième piston (15c) et ledit deuxième piston (15b) est relié à une première extrémité d'une deuxième tige (17b), portant à son extrémité opposée un quatrième piston (15d), ledit troisième piston (15c) et ledit quatrième piston (15d) définissant, conjointement avec les parois dudit boîtier, une troisième chambre de combustion (5c) formée dans une partie intermédiaire (3c) dudit boîtier,
à ladite première tige (17a) sont fixés un ou plusieurs premiers supports (23a) portant des ensembles de premiers aimants (25a) ou de premières bobines d'induction (27a), faisant face à des ensembles de premières bobines d'induction fixes (27a) ou de premiers aimants fixes, et à ladite deuxième tige (17b) sont fixés un ou plusieurs deuxièmes supports (23b) portant des ensembles de deuxièmes aimants (25b) ou de deuxièmes bobines d'induction (27b) qui font face à des ensembles de deuxièmes bobines d'induction fixes (27b) ou de deuxièmes aimants fixes, **caractérisé en ce que** ladite première chambre de combustion (5a) :

est équipée de moyens d'injection de carburant et de moyens d'allumage (7a) pour l'allumage de carburant ;

est également équipée d'un orifice d'admission (8a) en communication avec un conduit d'admission (9a) pour introduire de l'air dans ladite première chambre de combustion, ledit conduit d'admission (9a) étant en communication avec un conduit d'admission (11a) équipé d'un clapet d'admission (10a) ; et
est également équipée d'un orifice de sortie (12a) en communication avec un conduit d'échappement (13a) pour l'évacuation des gaz d'échappement de ladite première chambre de combustion (5a) ;
et dans lequel ladite deuxième chambre de combustion (5b) :

est équipée de moyens d'injection de carburant et de moyens d'allumage (7b) pour l'allumage de carburant ;
est également équipée d'un orifice d'admission (8b) en communication avec un conduit d'admission (9b) pour introduire de l'air dans ladite deuxième chambre de combustion, ledit conduit d'admission (9b) étant en communication avec un conduit d'admission (11b) équipé d'un clapet d'admission (10b) ; et
est en outre équipée d'un orifice de sortie (12b) en communication avec un conduit d'échappement (13b) pour l'évacuation des gaz d'échappement de ladite deuxième chambre de combustion (5b),

dans lequel ladite troisième chambre de combustion (5c) :

est équipée de moyens d'injection de carburant et de moyens d'allumage (7c) pour l'allumage de carburant ;
est également équipée de deux orifices d'admission (8c, 8d) en communication avec des conduits d'admission respectifs (9c, 9d) pour introduire de l'air dans ladite troisième chambre de combustion, l'un (9c) desdits conduits d'admission étant en communication avec ledit conduit d'admission (11a) de ladite première chambre de combustion (5a) par l'intermédiaire d'un clapet d'admission (10c), et l'autre (9d) desdits conduits d'admission étant en communication avec ledit conduit d'admission (11b) de ladite deuxième chambre de combustion (5b) par l'intermédiaire d'un clapet d'admission (10d) ; et
est en outre équipée de deux orifices de sortie (12c, 12d) en communication avec ledit conduit d'échappement (13a) de ladite première chambre de combustion et avec ledit conduit d'échappement (13b) de ladite deuxième chambre de combustion, respectivement, pour l'évacuation des gaz d'échappement de ladite troisième chambre de combustion.

2. Ensemble (1) selon la revendication 1, dans lequel ladite première tige (17a) et ladite deuxième tige (17b) sont agencées coaxialement, de sorte que ladite troisième chambre de combustion (5c) ait une forme sensiblement cylindrique.

3. Ensemble (1) selon la revendication 1 ou 2, dans lequel ladite première tige (17a) et ladite deuxième tige (17b) ont la même taille et la même masse, dans lequel lesdits premier et deuxième pistons (15a, 15b) ont la même taille et la même masse et dans lequel lesdits troisième et quatrième pistons (15c, 15d) ont la même taille et la même masse.

4. Ensemble (1) selon la revendication 3, dans lequel lesdits premier et deuxième pistons (15a, 15b) ont la même taille et la même masse que lesdits troisième et quatrième pistons (15c, 15d).

5. Ensemble (1) selon l'une quelconque des revendications 1 à 4, dans lequel deux premiers supports (23a) agencés à 180° l'un par rapport à l'autre sont fixés à ladite première tige (17a).

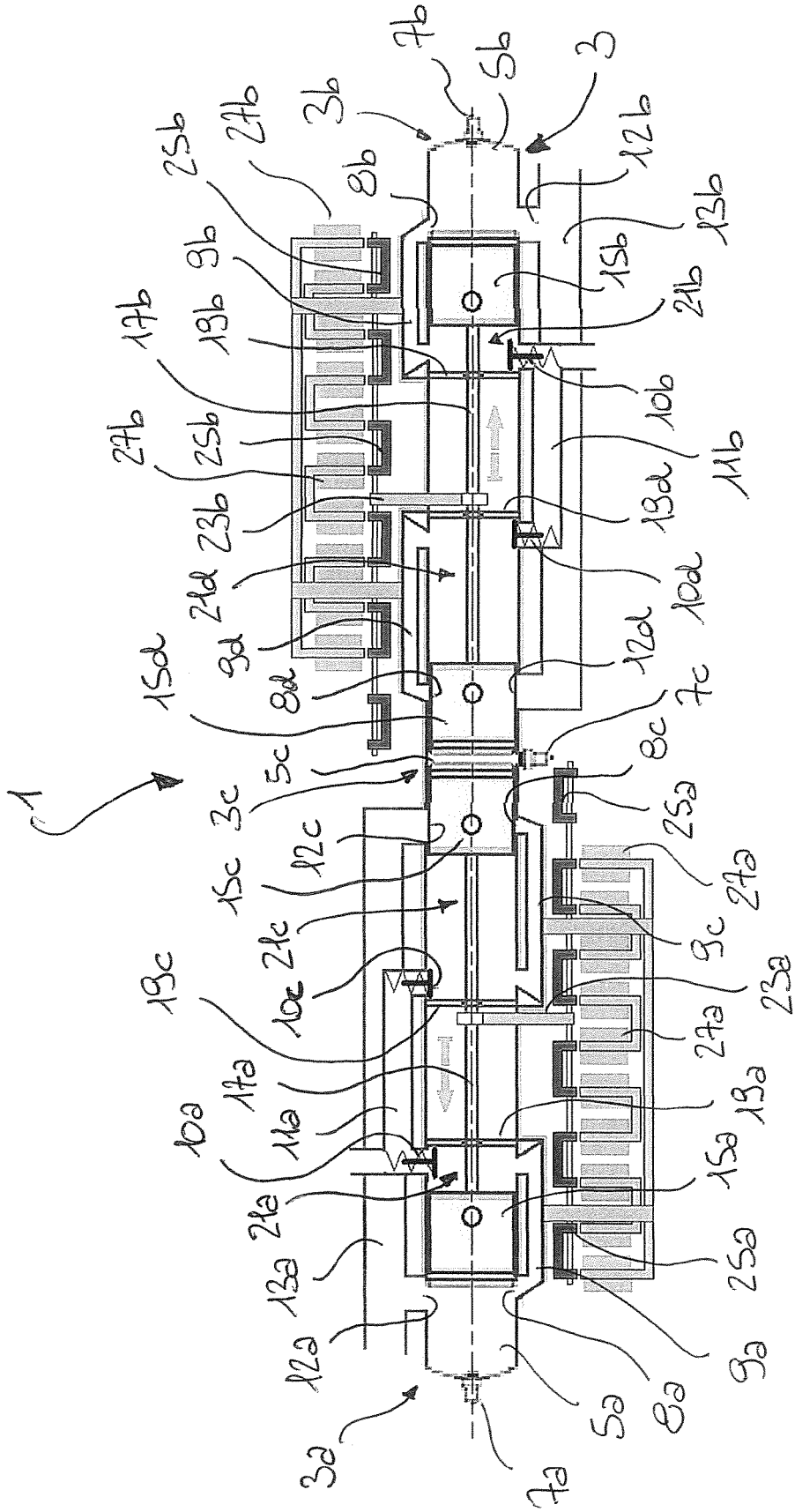
6. Ensemble (1) selon l'une quelconque des revendications 1 à 4, dans lequel deux deuxièmes supports (23b) agencés à 180° l'un par rapport à l'autre sont fixés à ladite deuxième tige (17b).

7. Ensemble (1) selon l'une quelconque des revendications 1 à 4, dans lequel deux premiers supports (23a) agencés à 180° l'un par rapport à l'autre sont fixés à ladite première tige (17a), dans lequel deux deuxièmes supports (23b) agencés à 180° l'un par rapport à l'autre sont fixés à ladite deuxième tige (17b), et dans lequel lesdits deuxièmes supports (23b) sont décalés de 90° par rapport auxdits premiers supports (23a).

8. Ensemble (1) selon l'une quelconque des revendications 1 à 4, dans lequel quatre premiers supports agencés à 90° les uns par rapport aux autres sont fixés à ladite première tige (17a), et dans lequel quatre deuxièmes supports agencés à 90° les uns par rapport aux autres sont fixés à ladite deuxième tige (17b).

9. Ensemble (1) selon l'une quelconque des revendications 1 à 8, dans lequel ladite première tige (17a) est montée sur des paliers longitudinaux (19a, 19c) définissant un premier espace (21a) qui est situé entre le premier piston (15a) et l'un (17a) desdits paliers et est en communication avec ledit conduit d'alimen-

tation (11a) de ladite première chambre de combustion et ledit conduit d'admission (9a) de ladite première chambre de combustion, et un deuxième espace (21c) qui est situé entre ledit troisième piston (15a) et l'autre (17c) desdits paliers et est en communication avec ledit conduit d'alimentation (11a) de ladite première chambre de combustion et ledit conduit d'admission (9c) de ladite troisième chambre de combustion, et dans lequel ladite deuxième tige (17b) est montée sur des paliers longitudinaux (19b, 19d) définissant un premier espace (21b) qui est situé entre le deuxième piston (15b) et l'un (17b) desdits paliers et est en communication avec ledit conduit d'alimentation (11b) de ladite deuxième chambre de combustion et ledit conduit d'admission (9b) de ladite deuxième chambre de combustion, et un deuxième espace (21d) qui est situé entre ledit quatrième piston (15d) et l'autre (17d) desdits paliers et est en communication avec ledit conduit d'alimentation (11b) et ledit conduit d'admission (9d) de ladite troisième chambre de combustion.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3a
3b
3c
3d
5a
5b
5c
7a
7b
8a
8b
8c
8d
9a
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9c
9d
10a
10b
10c
10d
11a
11b
12a
12b
12c
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13a
13b
13c
13d
15a
15b
15c
15d
17a
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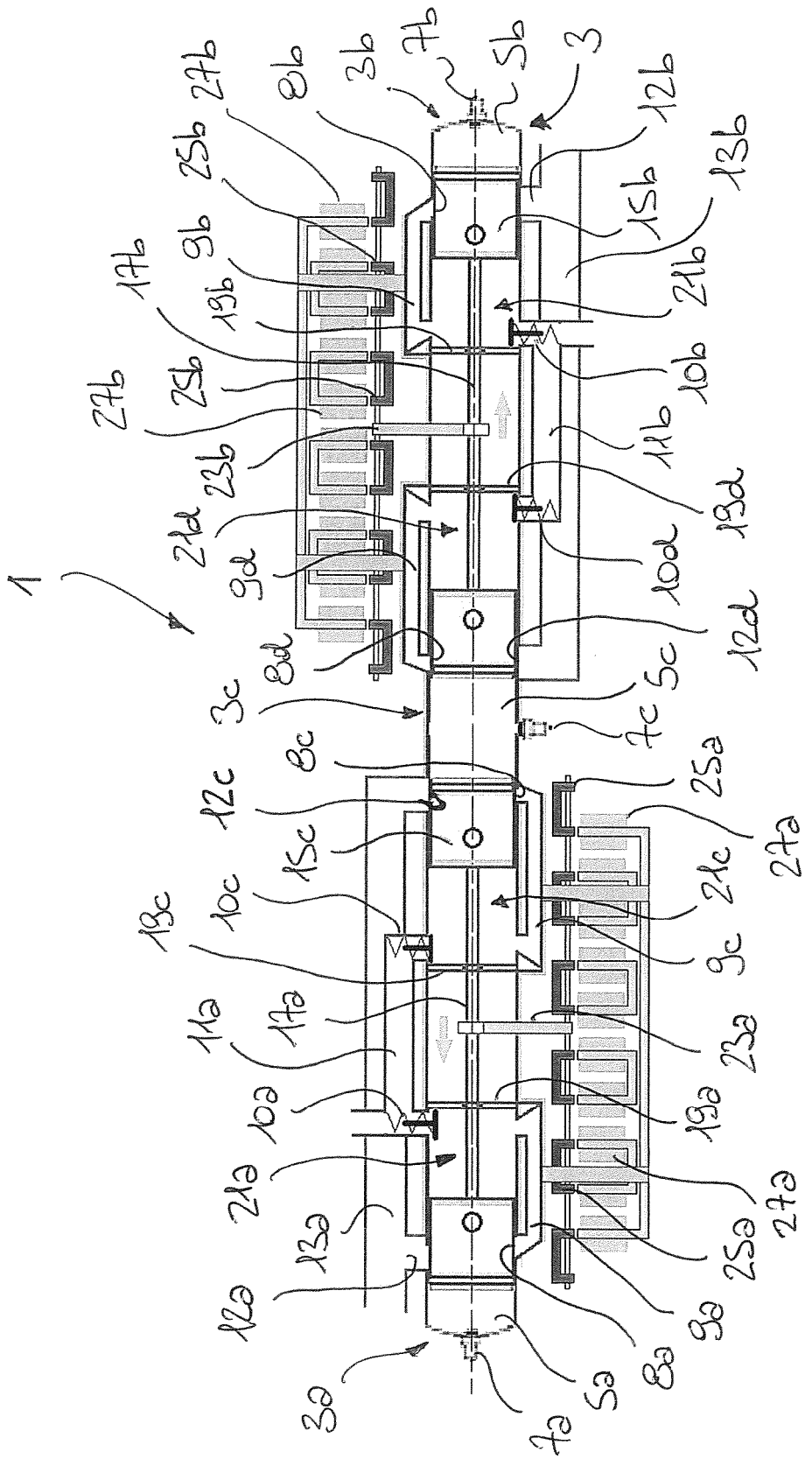
21d
23a
23b
25a
25b
27a
27b

FIG. 1a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3c
3d
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5c
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7b
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8c
8d
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9b
9c
9d
10a
10b
10c
10d
11a
11b
12a
12b
12c
12d
13a
13b
13c
13d
15a
15b
15c
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17b
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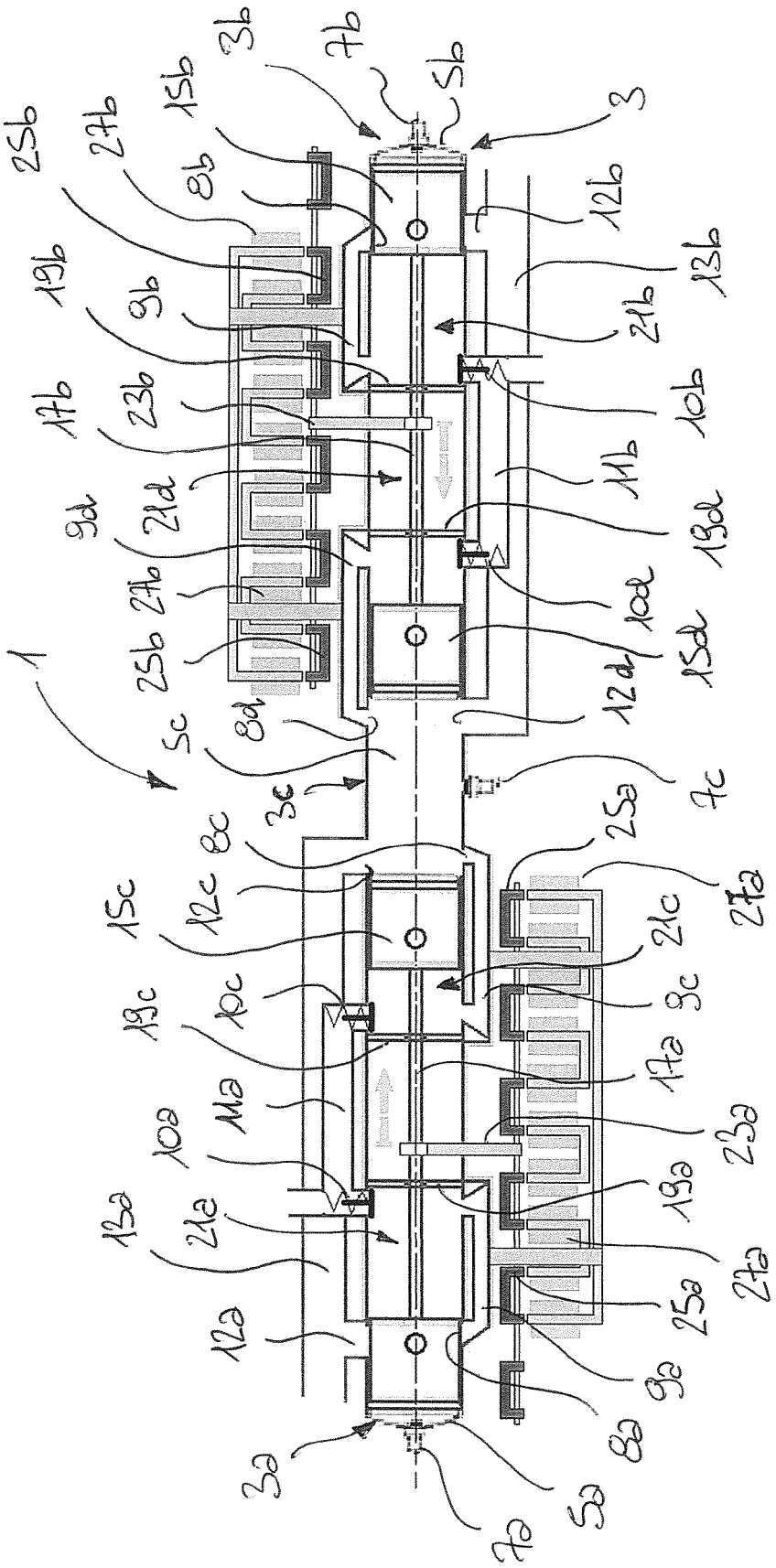
21b
21c
21d
23a
23b
25a
25b
27a
27b

FIG. 1b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3c
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10b
10c
11a
11b
11c
12a
12b
12c
12d
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13b
13c
13d
15a
15b
15c
15d
17a
17b
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21c
21d
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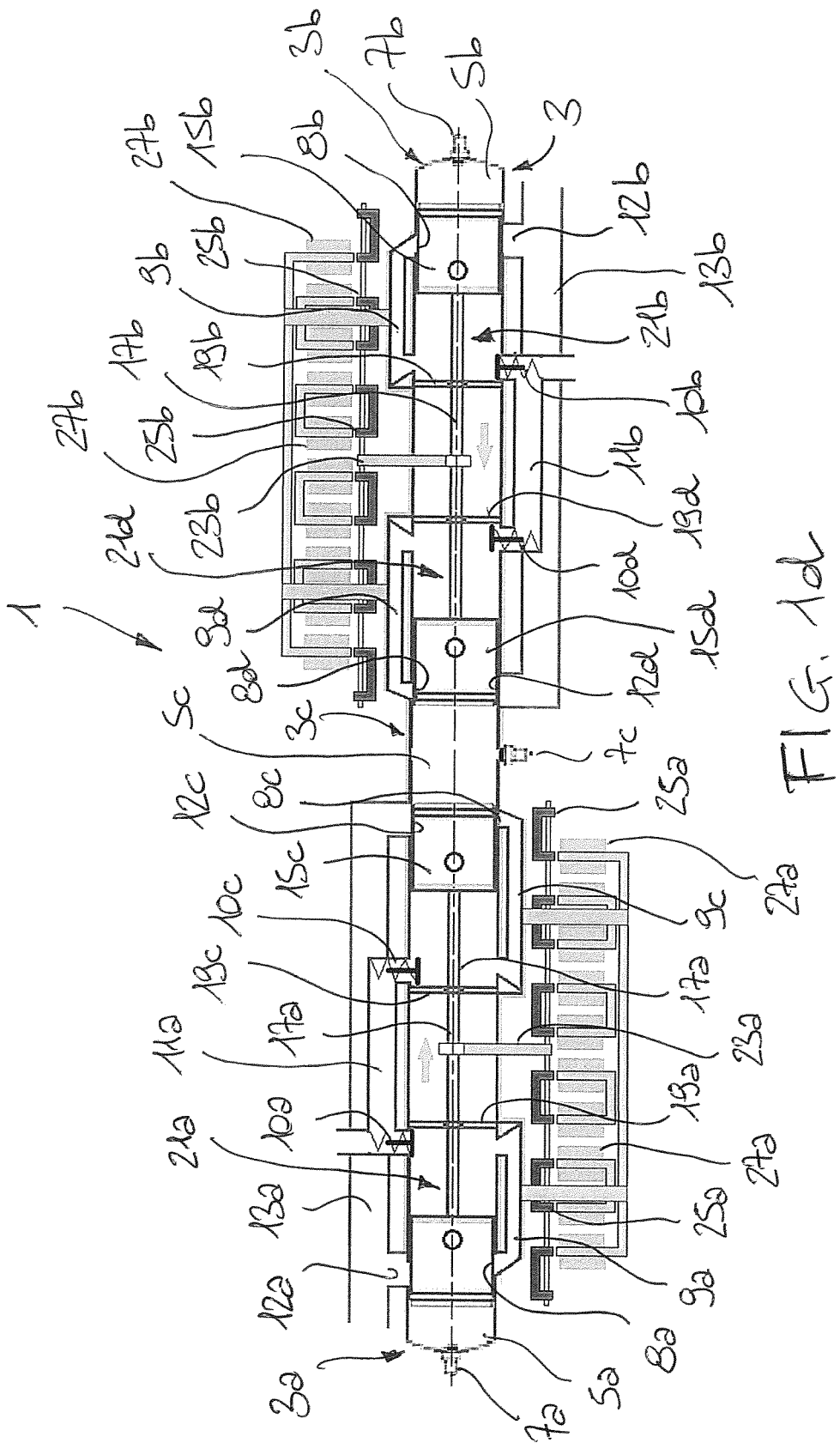
23b
25a
25b
27a
27b

FIG. 1c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2d
3a
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3c
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5a
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9a
9c
10a
10b
10c
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11b
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12b
12c
12d
13a
13b
13c
13d
15a
15b
15c
15d
17a
17b
23a
23b
25a
25b
27a
27b

FIG. 1d

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6349683 B **[0004]**
- US 20020139323 A **[0005]**
- US 3835824 A **[0008]**
- US 4924956 A **[0008]**
- WO 2011006797 A **[0008]**