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(54) RECIPROCATING PISTON INTERNAL COMBUSTION ENGINE AND TURBOCHARGER ASSEMBLY

(71) We, MASCHINENFABRIK AUGSBURG-NÜRNBERG AKTIENGESELLSCHAFT, a German company, of 8900 Augsburg, Stadtbachstrasse 1, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a reciprocating-piston internal combustion engine having an exhaust gas driven turbocharger assembly including at least two exhaust gas driven turbocharger units connected in parallel.

An object of the invention is to provide a reciprocating-piston internal combustion engine having an exhaust gas driven turbocharger assembly which enables the fluid flow machines, i.e. the exhaust gas driven turbines and the compressors or blowers, to be well matched to the reciprocating-piston engine at low cost, and such that the fluid flow machines can operate as far as possible independently of the operating condition of the engine and efficiently over the operating ranges of the engine from starting to small engine loads.

According to the present invention there is provided a reciprocating-piston internal combustion engine having an exhaust gas driven turbocharger assembly comprising at least two exhaust gas driven turbocharger units, disposed in parallel, the connecting lines of at least one of the exhaust gas driven turbocharger units to the engine being constructed such that they can be shut off, and the other or another of the exhaust gas driven turbocharger units is provided with a separate drive which is independent of the supply of exhaust gas to that unit whereby with that turbocharger unit driven by its separate drive the engine can be supplied with air adequately compressed for engine operation from starting up to operation at small engine loads. Each turbocharger unit preferably has a high-pressure turbine and a low-pressure turbine, and a low-pressure compressor and a high-pressure compressor.

In use, only one exhaust gas driven turbocharger unit, i.e. the one with a separate drive, is in operation on starting the engine and in the engine operation in the range of small loads, this turbocharger unit being optimally adjusted to the quantities of air and exhaust gas passing through it. Only in the case of higher loads and a correspondingly greater requirement of air for the engine and also with a greater quantity of exhaust gas from the engine can at least one further exhaust gas driven turbocharger unit then be connected.

The invention may be carried into practice in a number of ways but two specific embodiments will now be described, by way of example only, with reference to Figures 1 and 2 of the accompanying drawings, which each show a schematic illustration of an assembly comprising a reciprocating-piston internal combustion engine and two exhaust gas driven turbocharger units.

The assembly according to Figure 1 comprises the engine 1, more particularly a Diesel engine, which provides power, having an exhaust gas manifold 2 which is connected to two high-pressure exhaust gas driven turbines 5, 6 by way of respective connecting lines 3, 4. The outlet of each high-pressure turbine 5, 6 is connected via a respective duct 7, 8, forming an annular transfer duct for example, to the inlet of a respective low-pressure exhaust gas driven turbine 9, 10. The outlets of the two low-pressure turbines 9, 10 lead to atmosphere via exhaust silencers (not shown).

Each of the two low-pressure turbines 9, 10 is connected via a respective shaft 11, 12 to a respective low-pressure compressor 13, 14 each of which in this example draws in air from atmosphere. The outlet of each low pressure compressor is connected via a

respective line 15, 16 to the inlet of a high-pressure compressor 17, 18. In this case the high-pressure compressors 17, 18 are in driving connection with the high-pressure turbines 5 and 6 via the respective shafts 19, 20. To the shaft 20 there is also connected a drive motor 34, e.g. an electric motor, constituting a separate drive for the shaft 20.

Charge air intercoolers 21, 22 are respectively inserted in the lines 15, 16. Additionally a tap line 23, which leads via a relief valve 24 to the atmosphere, is connected to the line 15.

The outlets of the two high-pressure compressors 17, 18 are connected via respective connecting lines 25, 26 to a charge air collecting line 27, common to all the cylinders of the reciprocating-piston engine 1. Further charge air intercoolers 28, 29 are in this case disposed in each of the two connecting lines 25, 26. In addition, the connecting line 25 contains a shutoff valve 30. A corresponding shutoff valve 31 is provided in the connecting line 3 between the exhaust gas manifold 2 of the engine and the high-pressure turbine 5. Between the outlet of the high-pressure compressor 17 and the shutoff valve 30 there further proceeds from the connecting line 25 a tap line 32 which leads via a relief valve 33 to atmosphere. In other embodiments it may be possible to provide just one of the two relief valves 24, 33.

To start the engine 1 the two shutoff valves 30, 31 are closed, and the drive motor 34 is actuated to rotate the rotor of the turbine 6 and the impeller of the compressor 18. As soon as the charge air delivered by the compressor 18 has reached a predetermined compression ratio and a predetermined temperature, the engine 1 is started by way of a per se known starting device (not shown). The compressors 14, 18 are subsequently driven jointly by the exhaust gas driven turbines 6, 10 and by the drive motor 34; the latter is operated not only during starting of the engine but also in the range of small engine loads.

If the load of the engine 1 increases further until it emits such a considerable quantity of exhaust gas that the two exhaust gas driven turbines 6 and 10 can drive the compressors 14 and 18 alone then the drive motor 34 is switched off. In this load range the exhaust gas driven turbocharger unit 6, 18, 10, 14 now makes available the required quantity of charge air for the engine without the separate drive from the drive motor 34 being required. In this instance the exhaust gas driven turbocharger unit 6, 18, 10, 14 can be optimally designed for the part load range of the engine 1.

If the engine 1 is to be operated at fairly high load, then with corresponding increase in the fuel supply the shutoff valve 31 is first opened. Consequently a part of the exhaust gases can act on the exhaust gas driven turbines 5 and 9 so that a delivery of charge air from the compressors 13, 17 to the engine commences. To eliminate surging of the compressors 13 and 17 and to facilitate the acceleration of this exhaust gas driven turbocharger unit the relief valves 24 and/or 33 are initially opened. As soon as the compressor or outlet pressures of the compressors 13, 17 or the speeds of the two exhaust gas driven turbines 9, 5 have reached approximately equal values with those of the compressors 14, 18 or of the exhaust gas driven turbines 10, 6 the shutoff valve 30 is opened and the relief valves 24, 33 simultaneously closed. The second exhaust gas driven turbocharger unit 5, 17, 9, 13 now also conveys charge air into the charge air collecting line 27.

If the engine 1 is to be returned from full load to a part load range the shutoff valves 30 and 31 are closed and the relief valves 24, 33 opened simultaneously. The entire available quantity of exhaust gas thus now only acts on the exhaust gas driven turbocharger unit 6, 18, 10, 14 and delivery of charge air from the other exhaust gas driven turbocharger unit 5, 17, 9, 13 to the engine is discontinued.

The control of the shutoff valves 30, 31 is expediently effected automatically in dependence on the speeds of the two exhaust gas driven turbocharger units. The same applies to the relief valves 24, 33.

Expediently, the turbocharger units are of mutually identical construction, i.e. the two high-pressure turbines 5, 6 are constructed identically to one another, as are also the two low-pressure turbines 9, 10, and the two high-pressure compressors 17, 18, and the two low-pressure compressors 13, 14, so that a type simplification results for these parts.

Instead of two exhaust gas driven turbocharger units which include in each case a high-pressure and a low-pressure stage, three or more parallel-connected, two-stage, exhaust gas driven turbocharger units may be provided.

The use of at least two parallel-connected exhaust gas driven turbocharger units thereby facilitates not only the acceleration of the individual units but also gives rise to small external dimensions of the parts which can thus be built on to the engine 1 in space-saving manner.

In fundamental construction the assembly according to Figure 2 corresponds with the assembly according to Figure 1. The only difference is the provision of throttle valves 136, 137 respectively connected upstream of the inlets of the low-pressure compressor 113 and the high-pressure compressor 117. In other embodiments it may be possible to provide just one of the throttle valves 136,

137. The relief valves 24 and 33 may then be dispensed with. In principle, however, it is also possible to use the throttle valves 136, 137 together with the relief valves 24 and 33 according to Figure 1.

In the assembly according to Figure 2, as soon as the engine 101 together with the exhaust gas driven turbocharger unit 106, 118, 110, 114 runs alone in the part load range after switching off the drive motor 134 and the load of the engine is further increased, the shutoff valve 131 in the connecting line 103 is opened whilst the throttle valves 136, 137 and the shutoff valve 130 in the connecting line 125 are initially kept closed. Only after the compressor outlet pressures of the compressors 117, 113 or the speeds of the exhaust gas driven turbines 105, 109 correspond approximately to the compressor outlet pressures of the compressors 118, 114 or the speeds of the exhaust gas driven turbines 106, 110 are the throttle valves 136, 137 and the shutoff valve 130 simultaneously fully opened so that the charge air line 127 now also receives charge air from the second exhaust gas driven turbocharger unit.

WHAT WE CLAIM IS:—

1. A reciprocating-piston internal combustion engine having an exhaust gas driven turbocharger assembly comprising at least two parallel-connected exhaust gas driven turbocharger units, in which the connecting lines between at least one of the exhaust gas driven turbocharger units and the engine are constructed such that they can be shut off and in which the other or another of the exhaust gas driven turbocharger units is provided with a separate drive which is independent of the supply of exhaust gas to that unit whereby with that turbocharger unit driven by its separate drive the engine can be supplied with adequately compressed air for engine operation from starting up to operation at small engine loads.

2. An engine as claimed in claim 1, in which separate shutoff valves are provided in the connecting lines which extend between the engine and the said one exhaust gas driven turbocharger unit, and which respectively duct exhaust gas from, and compressed air to, the engine.

3. An engine as claimed in claim 1 or claim 2, in which each exhaust gas driven turbocharger unit has a high-pressure turbine and a low-pressure turbine, and a low-pressure compressor and a high-pressure compressor.

4. An engine as claimed in claim 3, in which a throttle valve is provided upstream of the inlet of the low-pressure compressor and/or a throttle valve is provided upstream of the inlet of the high pressure compressor of the said one exhaust gas driven turbocharger unit.

5. An engine as claimed in claim 3 when appendant to claim 2, or in claim 4 when appendant to claim 2, in which a relief valve is operatively arranged between the low-pressure compressor and the high-pressure compressor and/or a relief valve is operatively provided between the high-pressure compressor and the shutoff valve in the connecting line conveying charge air to the engine.

6. An engine as claimed in any one of the preceding claims, in which the exhaust gas driven turbocharger units are of mutually identical construction.

7. A reciprocating-piston internal combustion engine having an exhaust gas driven turbocharger assembly, substantially as specifically described herein with reference to the accompanying drawings.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

Fig.1

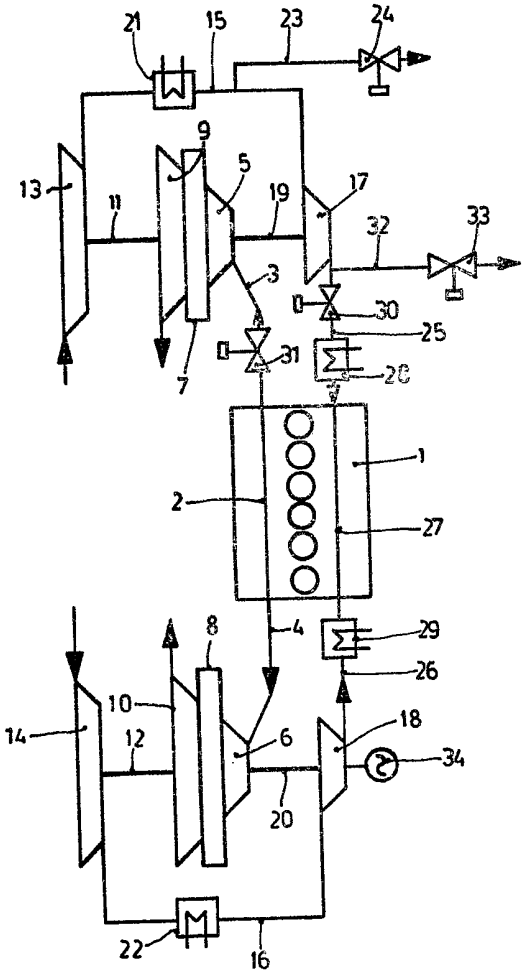
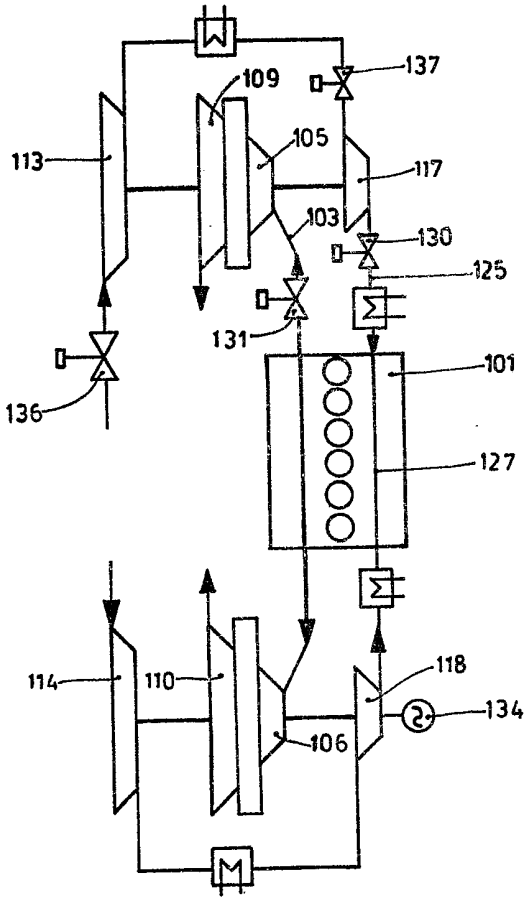


Fig.2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