



- (51) International Patent Classification:
F02B 41/10 (2006.01) F16H 47/06 (2006.01)
- (21) International Application Number:
PCT/EP2014/073212
- (22) International Filing Date:
29 October 2014 (29.10.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
13198840.4 20 December 2013 (20.12.2013) EP
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: A TURBOCOMPOUND ASSEMBLY, IN PARTICULAR IN THE FIELD OF INDUSTRIAL VEHICLES

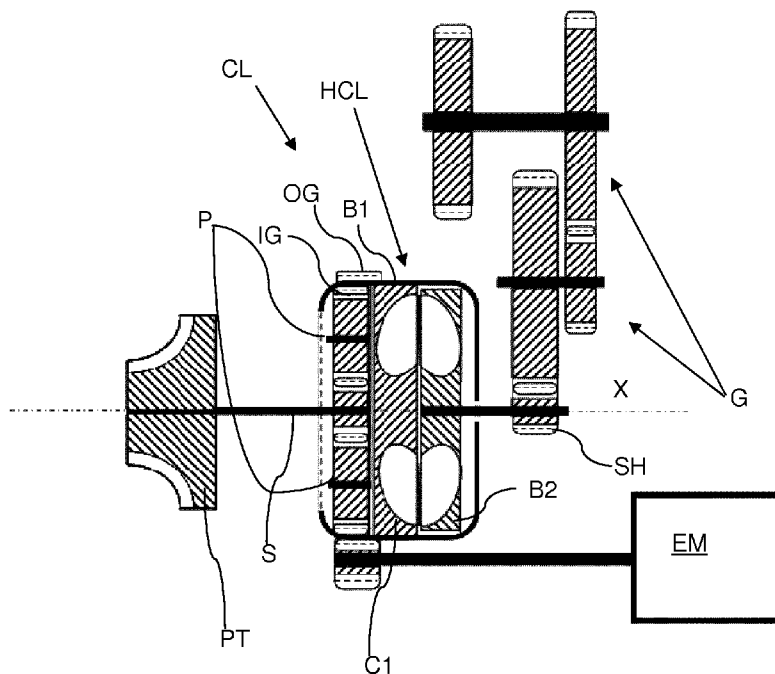


Fig. 3

(57) Abstract: A turbocompound assembly, in particular in the field of industrial vehicles, comprising a power turbine (PT) paired with the engine crankshaft, wherein the pairing is carried out through said assembly, wherein the assembly comprises a differential arrangement, wherein the pinion of the power turbine defines a sun gear (S) meshing into two or more planet gears (P), which in turn mesh into a ring gear (IG) coupled with the engine crankshaft.



Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

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**A TURBOCOMPOUND ASSEMBLY, IN PARTICULAR IN THE FIELD OF
INDUSTRIAL VEHICLES**

Field of the invention

The present invention relates to a turbocompound assembly, in
5 particular in the field of industrial vehicles.

Description of the prior art

Turbocompound systems are known since the late 60's.

For example the US patent N. 4100742 shows a classical
turbocompound configuration, wherein a first turbine driving
10 a compressor, while a second turbine, known as power turbine,
is geared with the crankshaft in order to help the combustion
engine.

A hydrodynamic coupling is commonly used in order to connect
the power turbine to the crank train. This type of connection
15 prevents the torsional vibrations of the crank shaft that are
magnified by the high gear ratios of the transmission between
crank shaft and turbine to affect the turbine.

Moreover, it is necessary to introduce a set of gears, linked
to the crank train, for adapting the revolution speed of the
20 power turbine with the revolution speed of the engine
crankshaft.

Due to the very high rotational speeds that are involved with
these pinions and bearings it is necessary to manufacture
these transmission with very tight dimensional tolerances, in
25 the order of single digit micrometers.

Summary of the invention

The main object of the present invention is to provide an improvement in the design of a turbocompound assembly, for connecting the power turbine with the crankshaft.

5 The main principle of the invention is that the power turbine shaft is coupled with the engine crankshaft, or crank train if further gears are present, through a differential device, where a pinion clamped directly on the power turbine shaft defines the sun of said differential device and the
10 ring gear of said differential device is coupled with the engine crankshaft.

The differential device is known also with other expression, such as Epicyclic gearing or plate drive.

Advantageously, according to a preferred embodiment of
15 the invention, the seats for the three components that are involved in the most critical dimensional pairings, are all integrated into one single metallic body, and can be machined all in one single clamping. These three components are the delicate bearing cartridge of the power turbine shaft, the
20 fast revving pinions geared to the power turbine shaft, the heavy power input side of the hydrodynamic coupling.

The pinion on the turbine shaft is the sun gear; the ring gear is an integral part of the coupling and the planets connect these two to form a planetary gear set. The power
25 turbine portion of the hydrodynamic clutch has a cylindrical

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shape having an inner annular gear and defining an axial symmetry and a corresponding symmetry axis. Therefore, the power turbine shaft lies on said symmetry axis and his pinion engages simultaneously said two or more gears, that, in turn, engage said inner annular gear. Thus, said two or more gears define planet gears, and the inner annular gear defines the ring of the planetary arrangement.

Preferably, the other portion of the hydrodynamic clutch, namely the portion designed to be coupled with the crank train has a closed basis having a second shaft, lying on said symmetry axis and provided with a pinion.

Therefore, a first object of the present invention is a turbocompound assembly.

A further object of the present invention is a vehicle comprising said turbocompound assembly.

These and further objects are achieved by means of the attached claims, which describe preferred embodiment of the invention, forming an integral part of the present description.

20 Brief description of the drawings

The invention will become fully clear from the following detailed description, given by way of a mere exemplifying and non limiting example, to be read with reference to the attached drawing figures, wherein:

25 - Fig. 1 shows a first view of the turbocompound assembly

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of the present invention,

- Fig. 2 shows a second view of the details of figure 1,
- Fig. 3 shows a schematic sectional view of the turbocompound assembly of previous figures;
- 5 - Fig. 4 shows a schematic sectional view of another embodiment of the turbocompound assembly according to the present invention;
- Fig. 5 shows turbocompound scheme implementing the turbocompound assembly of the previous figures.

10 The same reference numerals and letters in the figures designate the same or functionally equivalent parts.

Detailed description of the preferred embodiments

The assembly CL, according to figures 1 and 2, comprises a cylindrical body B1, defining a development axis X and an
15 corresponding axial symmetry.

Within the body B1 is arranged a differential arrangement, wherein the pinion of the power turbine PT defines a sun gear S meshing into two or more planet gears P, which in turn mesh into a ring gear
20 IG coupled with the engine crankshaft.

The ring gear, according to figure 2 and 3 is integral part with the body B1. Preferably, said ring gear is internally arranged as a meridian of the body B1.

25 Therefore, the power turbine shaft S lies on said

5

symmetry axis X and his pinion engages simultaneously two or more gears P that, in turn, engage said inner annular gear IG. Thus, said two or more gears define planet gears, radial arranged with respect to the sun S.

5 A carrier (not shown in figures 1 - 3) maintains planet gears P angularly equally spaced.

Within the body, preferably, is also arranged a hydrodynamic clutch HCL, thus the ring gear IG is coupled with the engine crankshaft through said
10 hydrodynamic clutch HCL.

The hydrodynamic clutch HCL comprises a first C1 and a second component B2 rotatably joined between each another according the development axis X, the latter defining a symmetry axis for the differential
15 assembly.

The first component C1 is fixed with the interior of said body B1, while the second component B2 is fixed with the shaft SH, that is suitable to be coupled with the engine crankshaft.

20 The shaft SH is provided with an annular gear, operatively paired with the crank train G, optional, for cooperating in adapting the power turbine speed with the crank shaft speed. Therefore, the second portion B2 is designed to be stably connected with the crankshaft K, through the crank train G if
25 present.

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The shaft S of the power turbine can comprise a bearing. According to a preferred embodiment of the invention, said bearing is integrated within said support B5. Or, alternatively, the body itself
5 defines a bearing for the power turbine shaft.

According to another preferred embodiment of the invention, disclosed on figure 4, the support B5 not only supports the power turbine shaft bearing B51, but also defines a carrier B52 for the planets P as
10 well as for the bearing B53 for the input side of the hydrodynamic coupling respectively for the ring gear that is integrated in that coupling..

Thus, a single body can comprise not only the Epicyclic assembly and the hydrodynamic coupling, but
15 also the power turbine shaft bearing. The power turbine support B5 is operatively fixed, while the body B1 (not shown in figure 4) rotates motored by the Epicyclic assembly. The second component B2 of the clutch, instead is fixed with the body B1 and the
20 first component C1 according to its oil pressure as in any known hydrodynamic coupling.

On figure 4 is shown the support B5 having an annular shape with a coaxial bearing B51 for the power turbine shaft S, and eccentric bearings B52 for the
25 planet gears P, parallel with the power turbine shaft

S.

The support B5, preferably, protrudes through the free space between the planets P, by interpenetrating with the portion B1/C1 of the assembly defining another rotatable interface with it, in particular another annular/coaxial bearing B53.

Being the first component C1 of the hydrodynamic coupling integral and fixed with the body B1, said rotatable interface can be obtained directly on the free face of the first component of the hydrodynamic clutch.

Although, in figure 4 is not shown the shaft SH, it is fixed with the portion B2 as shown in figure 3.

Advantageously, one single body encloses a differential device, a hydrodynamic clutch and a power turbine bearing.

Preferably, the single body B1 has a cylindrical shape, both internally and externally defining said axial symmetry X and has a further annular outer gear OG suitable to be paired with a power source or a load EM2 as shown on figure 5.

Implementation Example

According to figure 5 a combustion engine E, for example Diesel type, has an intake manifold In and an exhaust manifold Ex. A turbocharger unit T, C defines a first

supercharging stage (optional), having the first turbine T operatively connected immediately downstream of the exhaust manifold Ex. The compressor C, driven by the first turbine T, sucks fresh air from the ambient, compresses it, while the
5 intercooler unit CAC cools the compressed air before entering into the intake manifold In.

An EGR system and a waste gate valve WG can be implemented. In addition, the power turbine can be a variable geometry type.

10 A power turbine PT is arranged on the exhaust gas line IL, downstream said first turbine T, if present, according to the flow of the exhaust gasses.

Such power turbine is coupled with the engine crankshaft K through the turbocompound assembly disclosed above.

15 It follows that the power turbine is stably paired with an electric motor EM. The electric motor is electrically connected with means for storing electric energy ESM that could be of any type.

Control means CTRL control the operation of the clutch and of
20 the electric motor EM.

Many changes, modifications, variations and other uses and applications of the subject invention will become apparent to those skilled in the art after considering the specification and the accompanying drawings which disclose
25 preferred embodiments thereof. All such changes,

modifications, variations and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by this invention.

Further implementation details will not be described, as
5 the man skilled in the art is able to carry out the invention starting from the teaching of the above description.

CLAIMS

1. A turbocompound assembly, in particular in the field of industrial vehicles comprising a power turbine (PT) paired with the engine crankshaft, wherein said
5 pairing is carried out through said assembly, the assembly comprising
- a differential arrangement, wherein the pinion of said power turbine defines a sun gear (S) meshing into two or more planet gears (P), which in turn mesh
10 into a ring gear (IG) coupled with the engine crankshaft and
 - a hydrodynamic clutch (CL) so that said ring gear (IG) is coupled with the engine crankshaft through said hydrodynamic clutch (HCL) and
 - 15 - a body (B1) encloses said hydrodynamic clutch (HCL) and said ring gear (IG) is integral with said body (B1).
2. Assembly according to claim 1, wherein said hydrodynamic clutch (HCL) comprises a first (C1) and
20 a second (B2) components rotatably joined between each another according an axis (X), the latter defining a symmetry axis for the differential assembly and wherein said first component is stably fixed with said body (B1) and said second component
25 is integral with a shaft (SH) suitable to be coupled

with the engine crankshaft.

3. Assembly according to claim 2, further comprising a power turbine shaft support (B5), wherein said ring gear (IG), said power turbine shaft support (B5), a carrier of said planet gears are all seated in said single body (B1).

4. Assembly according to claim 3, wherein said power turbine shaft support (B5) defines said planet gear carrier.

5. Assembly according to claim 3 or 4, wherein said single body (B1) has a cylindrical shape, both internally and externally defining said axial symmetry (X).

6. Assembly according to any of the previous claims, wherein said differential arrangement has a further annular outer gear (OG) suitable to be paired with power source or load (EM).

7. Turbocompound system having a power turbine (PT), driven by the exhaust gasses of a combustion engine (E), paired with a crank train (G) through a turbocompound assembly according to any of the previous claims 1 - 8.

8. Turbocompound system according to claim 7, further comprising an electric motor/generator (EM) or an expander, geared with the power turbine (PT) through said annular outer gear (OG).

9. Turbocompound system according to claims 7 or 8, comprising a combustion engine (E) having

- a crankshaft (K),

- a first turbocharger system, wherein a first turbine
5 (T) drives a fresh air compressor (C),

- a power turbine (PT) arranged downstream of said first turbine (T), operatively coupled with said crankshaft (K) through said hydrodynamic clutch (CL) and said crank train (G).

10 10. Industrial vehicle comprising a turbocompound system, according to any of the previous claims from 7 to 9.

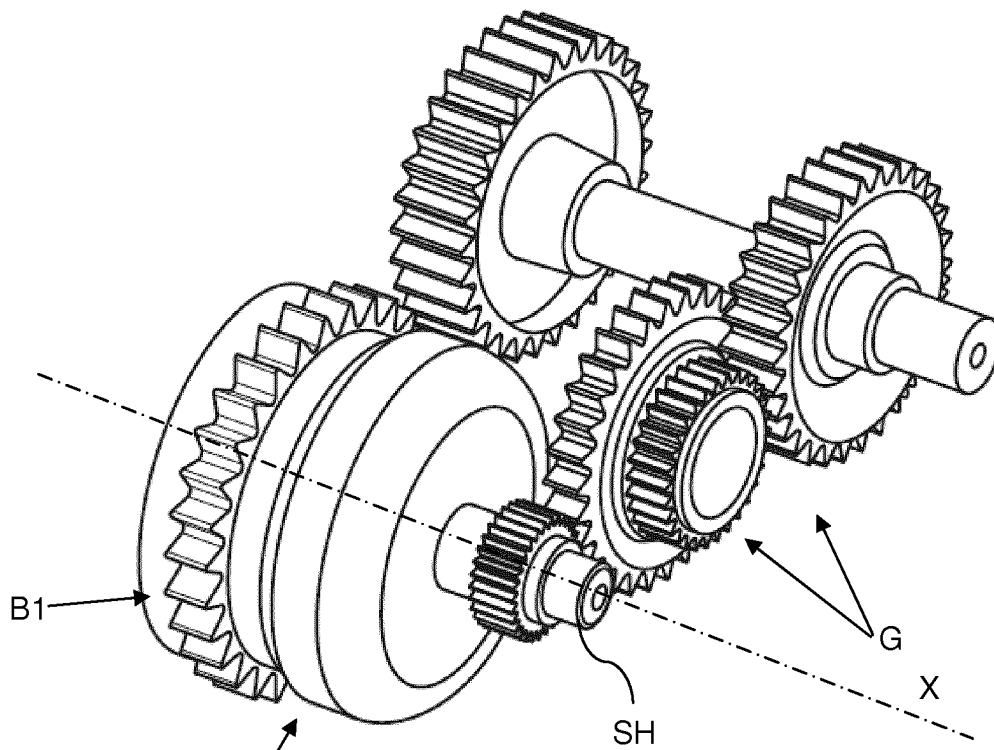


Fig. 1

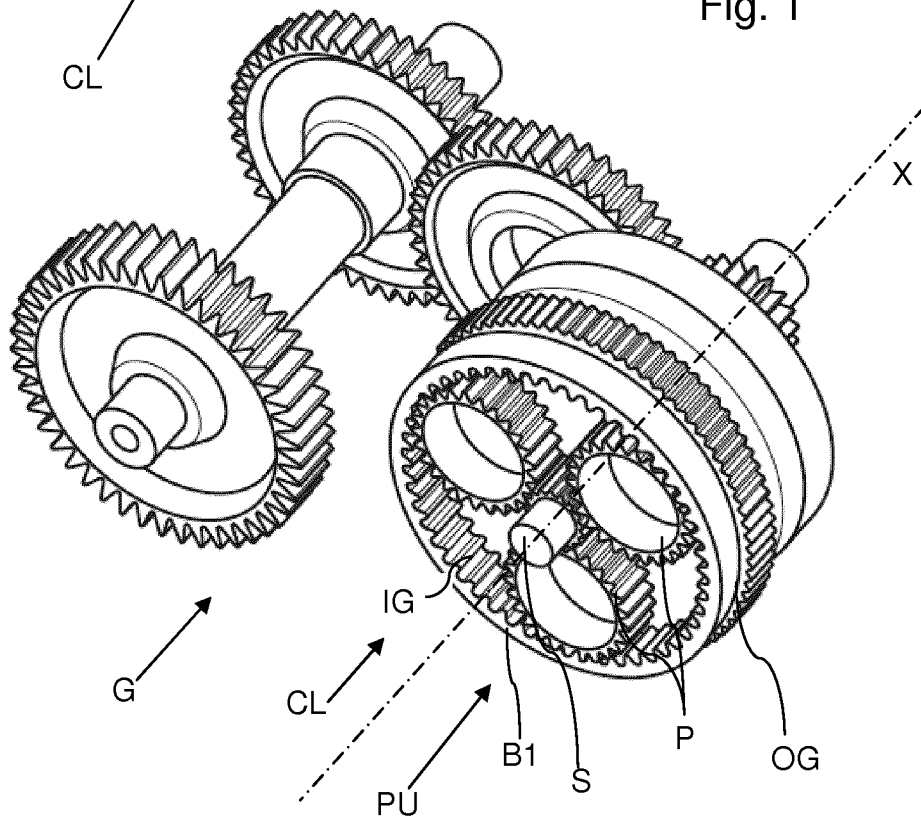


Fig. 2

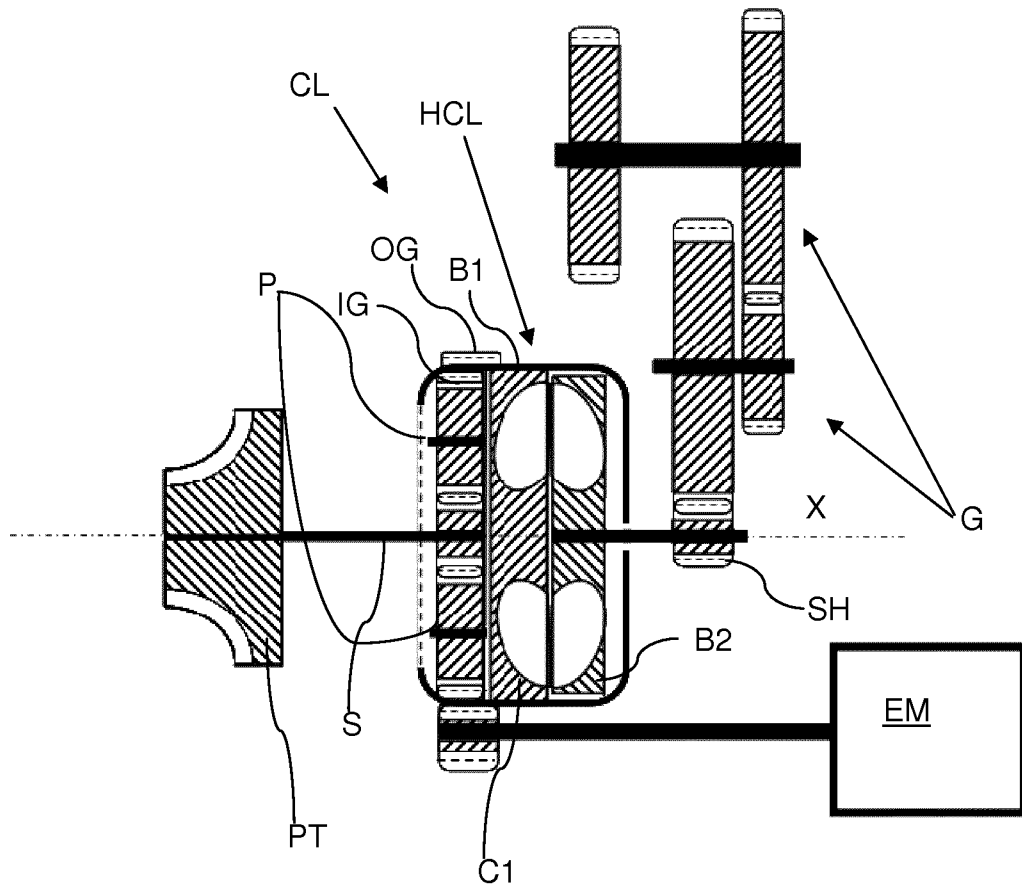


Fig. 3

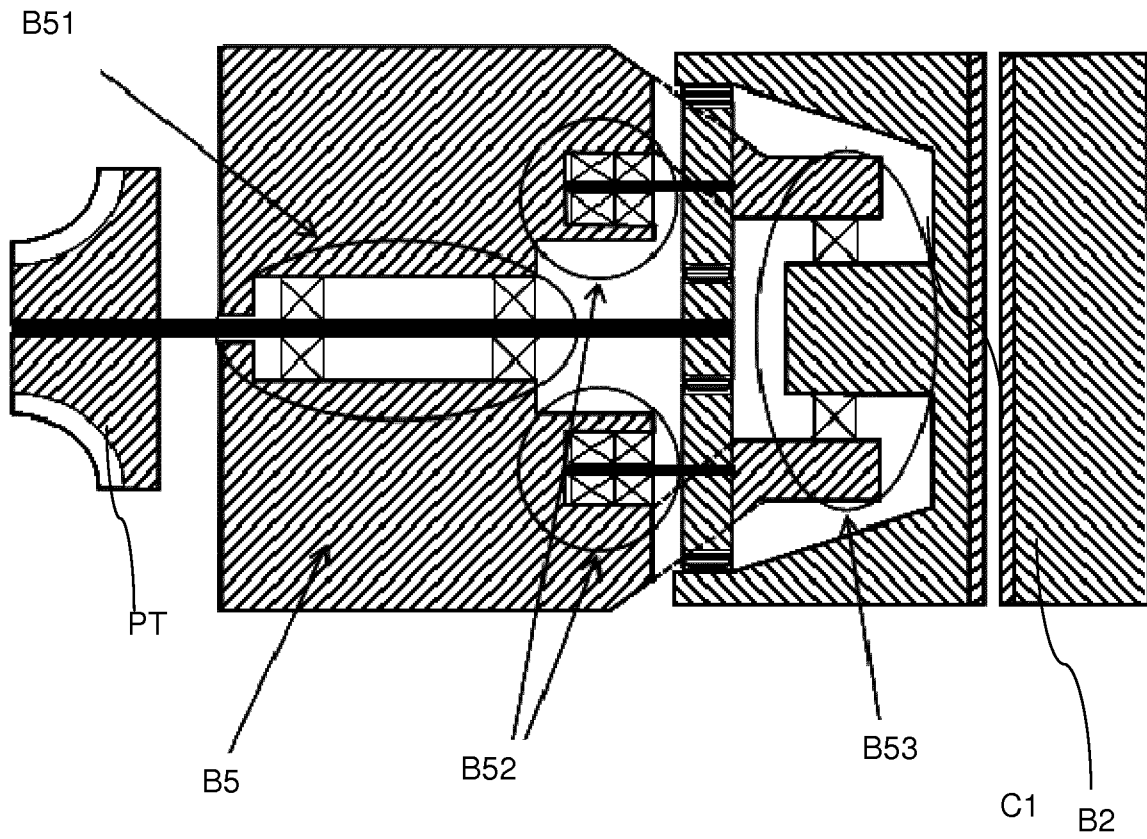


Fig. 4

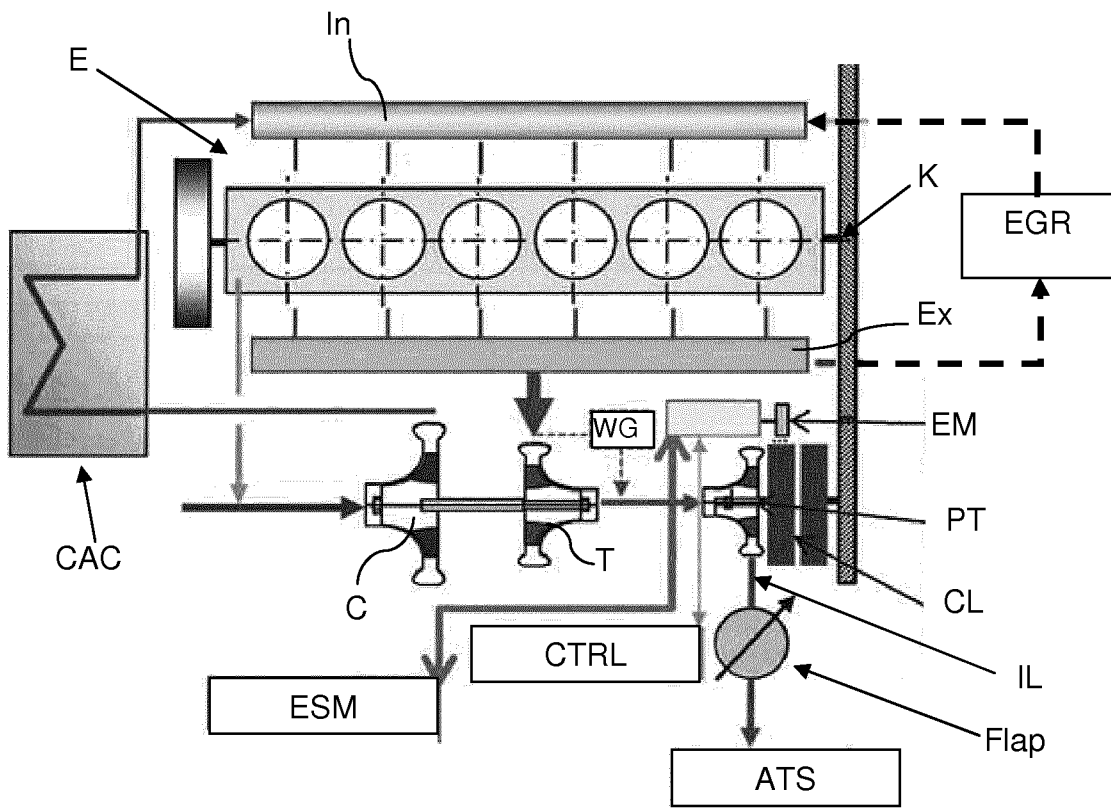


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/073212

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02B41/10 F16H47/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02B F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	column 3, line 2 - column 4, line 7; figure 1	8
Y	----- DE 102 04 066 A1 (VOITH TURBO KG [DE]) 14 August 2003 (2003-08-14) paragraph [0024] - paragraph [0030]; figures 1,2,4	8
Y	----- DE 10 2011 012861 A1 (VOITH PATENT GMBH [DE]) 6 September 2012 (2012-09-06) paragraph [0008] - paragraph [0030]; figures 1-3	1-10
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 January 2015	23/01/2015

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Tietje, Kai
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/073212

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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