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(54) Title: PLANETARY GEARSET FOR TURBOCOMPOUNDING APPLICATIONS

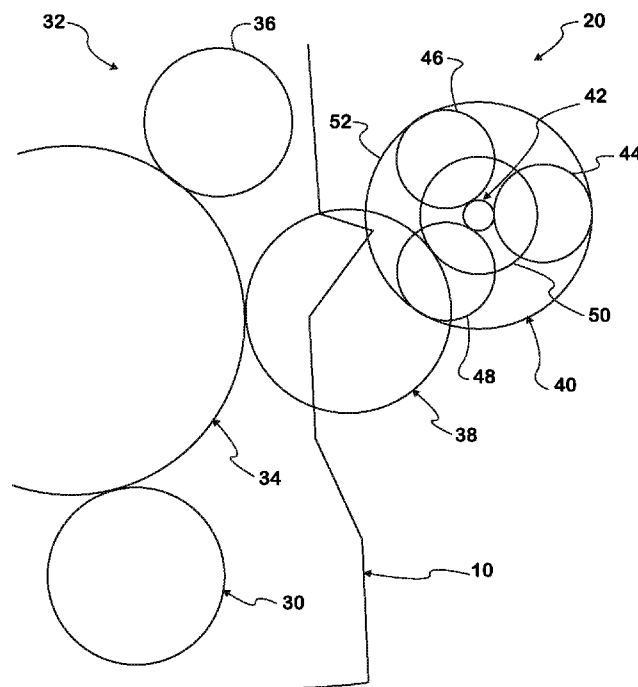


FIG. 2

(57) Abstract: A geartrain for connecting a turbocompounder to an internal combustion engine comprises a sun gear, a plurality of planet gears, a planet carrier, a ring gear, and an idler gear. Each of the plurality of planet gears engages the sun gear. The planet carrier connects to each of the plurality of planet gears. The plurality of planet gears engage the ring gear. The idler gear engages one of the planet carrier and ring gear and engages a geartrain of an internal combustion engine. An output shaft of the turbocompounder attaches to the sun gear.



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

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

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

Published:

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

PLANETARY GEARSET FOR TURBOCOMPOUNDING APPLICATIONS**DESCRIPTION****TECHNICAL FIELD**

[0001] The present disclosure relates to a gearset to connect a turbocompounder to an engine to allow power produced by a turbine within exhaust of the engine to be converted to mechanical energy at a geartrain of the engine, and more particularly to a planetary gearset to connect a turbocompounder to the geartrain of the engine.

BACKGROUND

[0002] Turbocompounders are known for use with internal combustion engines to convert a portion of the heat of exhaust into mechanical energy that is transferred back to a crankshaft of an engine or a geartrain that is driven by a crankshaft of an engine. As this heat would otherwise serve no useful purpose, turbocompounding has been viewed as a way to increase the power output of the engine, without having to combust additional fuel.

Turbocompounders have a turbine that is placed in fluid communication with exhaust from the engine. The flowing exhaust gas causes the turbine to rotate, thereby generating mechanical energy. Typically the turbocompounder is disposed downstream of a turbocharger within the exhaust from the engine.

[0003] Traditional turbocompounders have relied on a series of spur gears to allow the mechanical energy produced by the turbocompounder to be transferred to a crankshaft of the engine, a geartrain driven by the engine, a transmission coupled to the engine, or some other device couple to the engine or geartrain driven by the engine to receive the mechanical energy produced. The use of spur gears to transfer mechanical energy requires a plurality of gears, based on the disparity in operating speeds between the internal combustion engine and the turbocompounder. This plurality of gears takes a great deal of space to package, reducing the number of applications for an engine with a turbocompounder, as the gearing conflicts with space required for other components. Therefore a need exists for a system to connect a turbocompounder to an engine, to transfer mechanical energy from the turbocompounder to the engine, in a more compact manner.

SUMMARY

[0004] According to one embodiment, an internal combustion engine comprises a plurality of cylinders, a crankshaft, an engine geartrain, a turbocompounder, and a planetary

geartrain. The plurality of cylinders define a combustion chambers for combustion of fuel. Each of the plurality of cylinders has a reciprocating piston. The crankshaft is connected to each of the reciprocating pistons. The engine geartrain has a crankshaft drive gear. The crankshaft drive gear connects to the crankshaft and at least one driven gear that receives torque from the crankshaft drive gear. The turbocompounder is disposed in fluid communication with an exhaust system of the internal combustion engine. The turbocompounder has an output shaft. The planetary geartrain has a sun gear, a plurality of planet gears, a planet carrier connected to each of the plurality of planet gears, and a ring gear. The sun gear engages each of the plurality of planet gears. The plurality of planet gears engage the ring gear. The sun gear connects to the output shaft of the turbocompounder. The planetary geartrain couples to the engine geartrain.

[0005] According to another embodiment, a geartrain for connecting a turbocompounder to an internal combustion engine comprises a sun gear, a plurality of planet gears, a planet carrier, a ring gear, and an idler gear. Each of the plurality of planet gears engages the sun gear. The planet carrier connects to each of the plurality of planet gears. The plurality of planet gears engage the ring gear. The idler gear engages one of the planet carrier and ring gear and engages a geartrain of an internal combustion engine. An output shaft of the turbocompounder attaches to the sun gear.

[0006] According to a further embodiment, a turbocompounding assembly for an internal combustion engine comprises a turbine, a rotatable output shaft, and a planetary geartrain. The turbine is disposed in fluid communication with an exhaust system of the internal combustion engine. The rotatable output shaft couples to the turbine. The planetary geartrain has a sun gear, a plurality of planet gears, a planet carrier connected to each of the plurality of planet gears, and a ring gear. The sun gear engages each of the plurality of planet gears. The plurality of planet gears engages the ring gear. The sun gear connects to the output shaft. The planetary geartrain engages a geartrain of the internal combustion engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic diagram showing an engine having a turbocompounder.

[0008] FIG. 2 is a schematic view of an engine having a turbocompounder and a planetary gearset connecting the turbocompounder to the engine.

DETAILED DESCRIPTION

[0009] FIG. 1 shows an engine 10 having an exhaust system 12. The exhaust system 12 has an exhaust gas recirculation (“EGR”) portion 13. The EGR portion 13 has an EGR cooler 14 and an EGR valve 16. The EGR cooler 14 reduces the temperature of exhaust gas within the EGR portion 13. The exhaust system 12 additionally is shown as having a turbocharger turbine 18 and a turbocompounder 20. The turbocharger turbine 18 and the turbocompounder 20 are disposed in fluid communication with exhaust gas passing through the exhaust system 12. As shown in FIG. 1, the turbocompounder 20 is downstream of the turbocharger turbine 18.

[0010] The engine 10 additionally has an air intake system 22. The air intake system 22 has a first turbocharger compressor 24. A charge air cooler 28 is additionally provided to cool intake air within the air intake system 22. The turbocharger turbine 18 and the turbocharger compressor 24 form a turbocharger.

[0011] Turning now to FIG. 2, a schematic view of a rear portion of the engine 10 and the turbocompounder 20 are shown. The engine 10 has a crankshaft drive gear 30. The crankshaft drive gear 30 is coupled to a crankshaft of the engine 10 to transmit mechanical energy of the crankshaft to an engine geartrain 32. The engine geartrain 32 comprises an idler gear 34 and a driven gear 36. The driven gear 36 of the engine geartrain 32 is utilized to provide mechanical energy to a driven component such as a camshaft, a water pump, a fuel pump, an oil pump, or other components that may be driven by the engine geartrain 32.

[0012] The idler gear 34 is provided to allow the driven gear 36 to rotate in an identical direction, *i.e.*, clockwise or counterclockwise, to the crankshaft drive gear 30. As the idler gear directly engages both the crankshaft drive gear 30 and the driven gear 36, the idler gear has no effect on a gear ratio between the crankshaft drive gear and the driven gear 36, but rather allows the driven gear 36 to rotate in the same direction as the crankshaft drive gear.

[0013] A planetary gearset 40 is connected to the turbocompounder 20 (FIG. 1) to transfer mechanical energy generated by the turbocompounder to the engine 10. As shown in FIG. 2, the planetary gearset 40 is connected to the engine geartrain 32 via a turbocompounder idler gear 38.

[0014] The planetary gearset 40 comprises a sun gear 42, a plurality of planet gears 44, 46, 48, a planet carrier 50, and a ring gear 52. The sun gear 42 is coupled to an output shaft of the turbocompounder 20. The sun gear 42 simultaneously engages each of the planet gears 44, 46, 48. The planet carrier 50 is connected to each of the planet gears 44, 46, 48. The planet carrier 50 engages the turbocompounder idler gear 38 to transfer mechanical energy from the turbocompounder 20 to the engine 10.

[0015] Each of the planet gears 44, 46, 48 also engage the ring gear 52. The ring gear 52 has teeth on an inner peripheral surface, while the sun gear 42, plurality of planet gears 44, 46, 48, and planet carrier 50 have teeth on an outer peripheral surface.

[0016] Depending on which of the sun gear 42, the plurality of planet gears 44, 46, 48 and the ring gear 52 are allowed to rotate, different gear ratios may be obtained from the planetary gearset 40. For instance, the gear ratio is different if the ring gear 52 is held stationary, the planet carrier 50, plurality of planet gears 44, 46, 48, and the sun gear 42 all rotate, than if the sun gear 42 is held stationary and the rest of the gears of the planetary gearset 40 are allowed to rotate. In this way, the planetary gearset 40 provides a compact arrangement of gears that provide variable gear ratios, such that the output of the turbocompounder 20 may be at a rotational speed that is generally equal to that of the engine.

[0017] Thus, a compact packaging solution for a geartrain to couple the turbocompounder 20 to the engine 10 is provided by the planetary gearset 40.

CLAIMS

What is claimed is:

1. An internal combustion engine comprising:
 - a plurality of cylinders defining combustion chambers for combustion of fuel, each of the plurality of cylinders having a reciprocating piston;
 - a crankshaft connected to each of the reciprocating pistons;
 - an engine geartrain having a crankshaft drive gear, the crankshaft drive gear being connected to the crankshaft and at least one driven gear receiving torque from the crankshaft drive gear;
 - a turbocompounder disposed in fluid communication with an exhaust system of the internal combustion engine, the turbocompounder having an output shaft; and
 - a planetary geartrain having a sun gear, a plurality of planet gears, a planet carrier connected to each of the plurality of planet gears, and a ring gear, the sun gear engaging each of the plurality of planet gears, the plurality of planet gears engaging the ring gear, the sun gear connected to the output shaft of the turbocompounder, the planetary geartrain being coupled to the engine geartrain.
2. The internal combustion engine of claim 1, further comprising a planetary idler gear that couples the planetary geartrain to the engine geartrain.
3. The internal combustion engine of claim 2, further comprising an engine idler gear, the planetary idler gear directly engaging the engine idler gear.
4. The internal combustion engine of claim 2, wherein the planet carrier directly engages the planetary idler gear.
5. The internal combustion engine of claim 1, further comprising a turbocharger, the turbocharger being disposed in the fluid communication with the exhaust system of the internal combustion engine, the turbocharger being disposed upstream in the exhaust system of the turbocompounder.
6. The internal combustion engine of claim 1, wherein the engine geartrain is disposed proximate a rear portion of the internal combustion engine.
7. The internal combustion engine of claim 1, wherein the planetary geartrain is coupled to the engine geartrain at a driven gear.
8. A turbocompounding assembly for an internal combustion engine comprising:
 - a turbine disposed in fluid communication with an exhaust system of the internal combustion engine;
 - a rotatable output shaft coupled to the turbine;

a planetary geartrain having a sun gear, a plurality of planet gears, a planet carrier connected to each of the plurality of planet gears, and a ring gear, the sun gear engaging each of the plurality of planet gears, the plurality of planet gears engaging the ring gear, the sun gear being connected to the output shaft, wherein the planetary geartrain engages a geartrain of the internal combustion engine.

9. The turbocompounding assembly for an internal combustion engine of claim 8, wherein a planetary idler gear engages the planetary geartrain and the engine geartrain.

10. The turbocompounding assembly for an internal combustion engine of claim 9, wherein the planet carrier directly engages the planetary idler gear.

11. The turbocompounding assembly for an internal combustion engine of claim 8, wherein the planetary geartrain engages an engine geartrain at a rear portion of the internal combustion engine.

12. The turbocompounding assembly for an internal combustion engine of claim 8, wherein the plurality of planet gears comprises three planet gears.

13. The turbocompounding assembly for an internal combustion engine of claim 8, wherein the sun gear has a smaller diameter than at least one of the planet gears.

14. The turbocompounding assembly for an internal combustion engine of claim 8, wherein the sun gear has a smaller diameter than the ring gear.

15. A geartrain for connecting a turbocompounder to an internal combustion engine comprising:

a sun gear;

a plurality of planet gears, each of the plurality of planet gears engaging the sun gear;

a planet carrier connected to each of the plurality of planet gears;

a ring gear, the plurality of planet gears engaging the ring gear; and

an idler gear engaging one of the planet carrier and ring gear and engaging a geartrain of an internal combustion engine, wherein an output shaft of the turbocompounder attaches to the sun gear.

16. The geartrain for connecting a turbocompounder to an internal combustion engine of claim 15, wherein the engine geartrain is disposed at a rear portion of the internal combustion engine.

17. The geartrain for connecting a turbocompounder to an internal combustion engine of claim 15, wherein the sun gear has a smaller diameter than at least one of the planet gears.

18. The geartrain for connecting a turbocompounder to an internal combustion engine of claim 15, wherein the sun gear has a smaller diameter than the ring gear

19. The geartrain for connecting a turbocompounder to an internal combustion engine of claim 15, wherein the plurality of planet gears comprises three planet gears.

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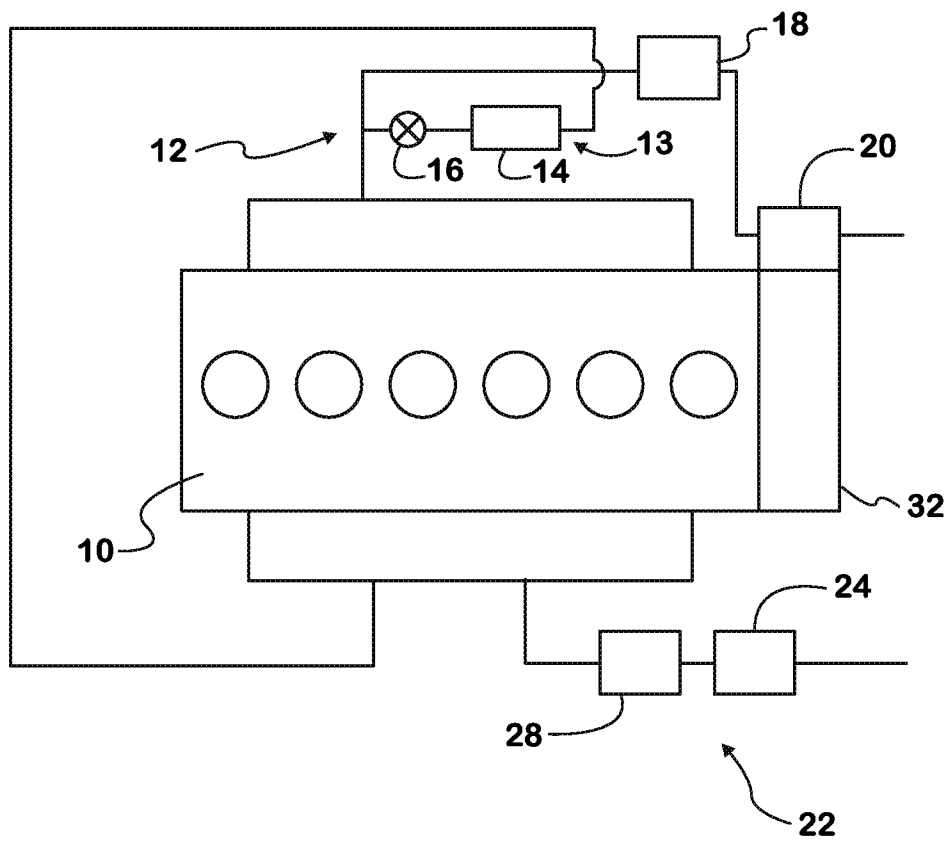


FIG. 1

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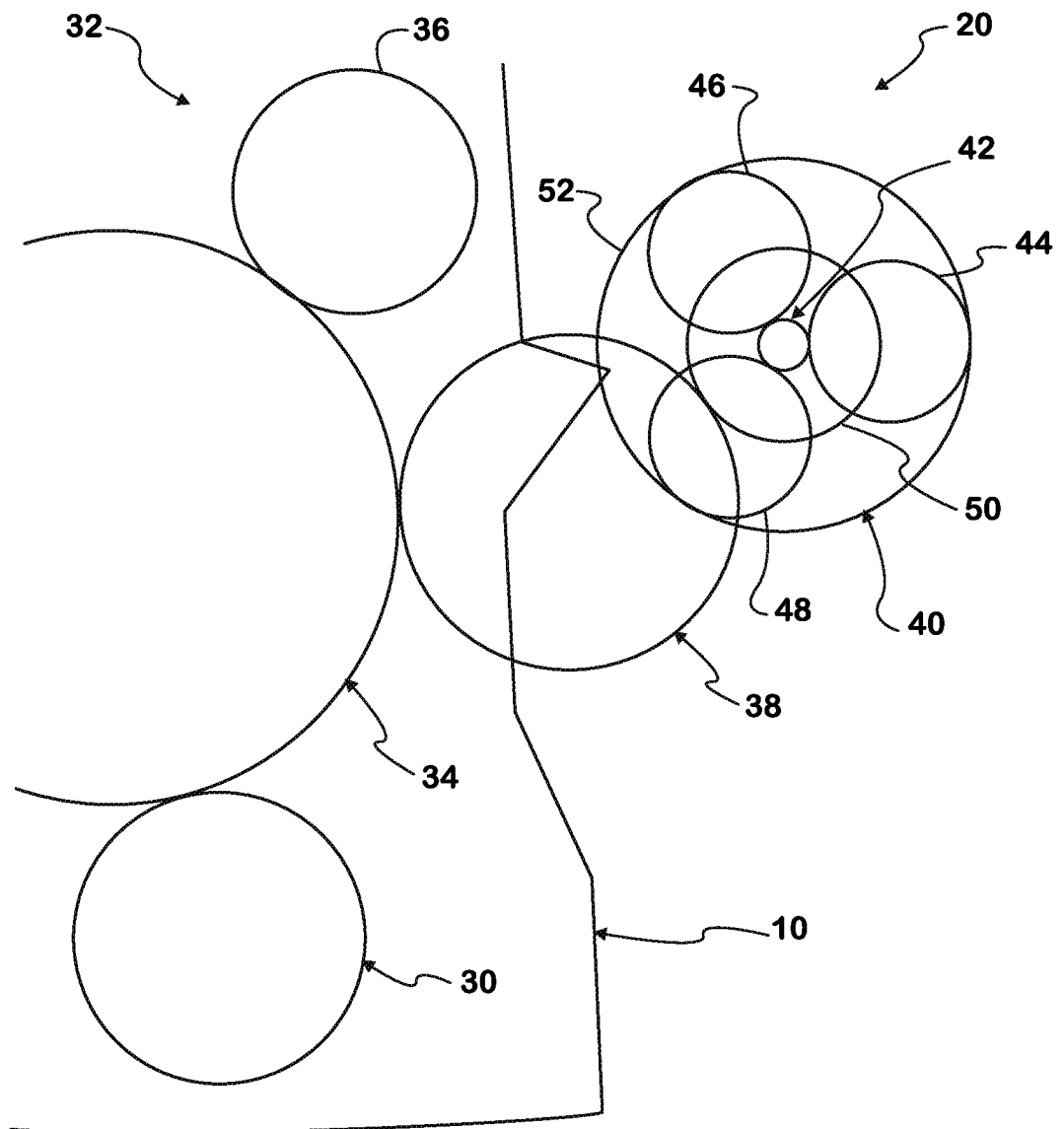


FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US2011/022308

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F02B 33/44 (2011.01)

USPC - 60/605.1

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)

IPC(8) - F02B 33/44 (2011.01)

USPC - 60/598, 605.1, 605.2, 607, 624; 123/559.1

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)

MicroPatent, Google Patents

Search terms used: planetary, gears, turbocompounder, engine, turbocharger, geartrain, supercharger, turbocompound, ring, gear, sun, idler

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/0032225 A1 (DYNE et al) 16 February 2006 (16.02.2006) entire document	1-19
A	US 4,586,337 A (FOX) 06 May 1986 (06.05.1986) entire document	1-19

☐ Further documents are listed in the continuation of Box C.


* Special categories of cited documents:

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

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"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

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Date of the actual completion of the international search

04 March 2011

Date of mailing of the international search report

14 MAR 2011

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