Title: SEALING ARRANGEMENT FOR TURBO COMPOUND UNIT AND COMBUSTION ENGINE INCLUDING SUCH A UNIT

Abstract: A sealing device (34, 35; 37) for a housing (14) for a turbocompound unit (5) which incorporates an output shaft (10) which is arranged to transmit power from the power turbine to a flywheel of the combustion engine. The device is distinguished by a first sealing portion (34; 38) for placing radially round and in sealing cooperation with a shell surface for a protruding bearing abutment (15) which is arranged for a bearing (33) for the output shaft (10) of the turbocompound unit (5) and which is intended for guidance cooperation with a transmission plate (30) fastened to the engine block (2), and a second sealing portion (35, 39) for placing radially outside the bearing abutment (15) and adapted to sealing axially between and catering for variation of the axial distance between, the housing (14) and the transmission plate (30).
Sealing arrangement for turbo compound unit and combustion engine including such a unit

Technical field

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The present invention relates to a sealing device for a turbocompound unit according to the preamble to patent claim 1. The invention also relates to a combustion engine including such a device.

State of the art

Turbocompound units are used for utilising part of the energy content of the exhaust gases from a combustion engine. To this end, the unit is situated in the exhaust line so that the exhaust gases drive a power turbine of the unit. The latter, by means of its shaft, two sets of mechanical gears and a hydraulic coupling, provides the engine's power transmission with extra power as a result of the output shaft of the unit being designed to cooperate with the engine’s flywheel.

In the case of a turbocharged engine with turbine-driven inlet air compressor, the power turbine of the turbocompound unit is situated downstream from the turbocharging unit.

A conventional turbocompound unit incorporates a first set of gears between the power turbine and the hydraulic coupling. A second set of gears is situated after the hydraulic coupling and includes a gearwheel on the unit’s output shaft and an intermediate gear between this and a crankshaft gearwheel which is rigidly connected to the engine’s flywheel. The conventional turbocompound unit is fastened by its housing to the outside of a flywheel casing which encloses the flywheel, the intermediate gear and the crankshaft gearwheel. The unit’s output shaft passes through a recess in the casing. For sealing purposes an O-ring has been inserted which seals radially between the flywheel casing and a housing section which surrounds the output shaft and is guided in a hole in the flywheel casing.
Turbocompound technology involves a source for increasing the power and reducing the fuel consumption of combustion engines, particularly in the case of turbocharged diesel engines for heavy vehicles. However, the technology has been called into question not only on the basis of the additional cost of the unit but also because of problems of operational reliability. In particular, experience has revealed limited service life of the mechanical gear after the hydraulic coupling, involving gearwheel damage requiring inspection, repair and sometimes unit replacement.

Objects and most important characteristics of the invention

One object of this invention is to indicate a sealing device which makes it possible to reduce the problems of the state of the art and is suitable for a turbocompound unit which is so arranged as to make possible a reliable and long-lasting solution whereby the need for repairs can be reduced.

This object is achieved according to the invention with a sealing device for a turbocompound unit of the kind mentioned in the introduction having the features indicated in the characterising part of patent claim 1.

The fact that the sealing device thus incorporates both first and second sealing portions arranged in this way results in the achievement of reliable sealing against oil leaking out along the bearing abutment towards the housing. It also results in the region on the housing side of the transmission plate, between the housing and the plate, being effectively protected from ingress of dirt even if the distance and hence the gap between the housing and the plate may be subject to variation. In the first place dirt making its way in this region would be very difficult to eliminate. In the second place, if only a radial seal was present, such dirt might make its way in behind it and in course of time affect its sealing function. The second sealing portion thus has a protective function vis-a-vis the first sealing portion.

By means of the sealing device according to the invention, the housing can be arranged for oriented fastening to the engine block and not, as in conventional technology, to the flywheel casing. This arrangement prevents incorrect engagement between the gearwheel
on the turbocompound unit's output shaft and cooperating gearwheels. This is because placing the unit on the engine block gives the unit’s output shaft an alignment which corresponds in parallelism with the gearwheels with which the output shaft’s gearwheel has to engage. This contrasts with a unit which, according to conventional technology, is attached to the flywheel casing and is therefore subject to bending movements and vibrations which occur during operation between the engine and the vehicle’s gearbox. These movements have been found to affect gear engagement precision and hence gradually in serious cases to lead to gear damage. The invention results instead in more reliable gear engagement and substantially longer service life.

The invention thus makes the sealing function possible even if the gap between the housing and the transmission plate is of a different width, as will naturally occur with different engines and housings, since the present fitting of the turbocompound housing involves these being fitted with precision as regards minimising of shaft angle deviation, and not with regard to positioning in the shaft direction.

It is preferable that the sealing device should consist of two sealing portions integrated to form a single sealing ring. This results in manufacturing and handling advantages and makes it possible for the sealing ring seat to be simplified, since no special guide surfaces for the second sealing portion need be provided. In particular, no groove or the like need be formed on the outer shell surface of the abutment, which therefore needs no machining in this respect.

Further advantages are achieved by the features indicated in the other dependent claims, and will be indicated in the following description of an embodiment.

**Brief description of the drawings**

An embodiment of the invention will now be described with reference to the drawings, in which:
Fig. 1 depicts schematically a turbocompound unit in conjunction with a turbocharged combustion engine.

Fig. 2 depicts part of a housing for a turbocompound unit in a first sideview.

Fig. 3 depicts the housing in Fig. 2 viewed from below,

5 Fig. 4 depicts a sectional view through the housing in Figs. 2 and 3 in cooperation with a transmission plate and with a first embodiment of a sealing device, and

Fig. 5a and b depict partial sections of a second embodiment of a sealing device at different stages of fitting.

10 Description of an embodiment

In Fig. 1 ref. 1 denotes a turbocharged diesel engine for a heavy vehicle. The engine is equipped in a conventional manner with arrangements for cooling of charge air and radiator fluid. Ref. 2 denotes an engine block and ref. 3 an exhaust manifold which leads 15 the exhaust gases from cylinders of the engine to a turbocharging unit 4. Situated downstream from the turbocharging unit 4, as viewed in the exhaust line, is a power turbine 6 of a turbocompound unit 5.

The power turbine 6 has running from it a turbine shaft 7 for transmitting power 20 generated by the power turbine, via a first gear set 8, to a hydraulic coupling 9 which is inserted to allow speed differences between the input and output shafts of the coupling.

A second gear set 11 is then arranged to further reduce the speed of the turbocompound unit 5 and allow cooperation between the shaft and the flywheel 12. Ref. 13 denotes a 25 casing for the flywheel, a casing which in the conventional solution supports the turbocompound unit 5, a practice which does not apply to the unit according to the invention. For comprehension of the approximate combined gear ratio of the gear sets, it may be stated that the speed of the power turbine may range up to several tens of thousands of revolutions per minute, e.g. 60,000 rpm, while the flywheel speed during 30 normal cruising of the vehicle ranges up to about 1100 rpm.

Fig. 2 depicts a section 14 of a housing for a turbocompound unit according to the invention. In principle, the construction of this unit is the same as the unit in Fig. 1. The
same reference notations are used for corresponding parts. A cover (not depicted in this
diagram) is intended to be fitted to the surface 14'. The housing also includes a bearing
abutment 15 to accommodate a roller bearing for the output shaft. Ref. 16 denotes an oil
outlet from the unit.

The unit's housing is designed to cooperate positionally with the engine block for a
combustion engine. To this end, the housing incorporates a number of contact portions
and guides for cooperation with corresponding aligning surfaces on the engine block.

First contact portions 17 and 20 have respective contact surfaces 18 and 21 which
cooperate with first aligning surfaces P1 and P2 respectively on the engine block. These
first contact portions 17, 20 also constitute fixing portions in that each of them is provided
with a drilled hole in which a screw (hinted at by broken lines at 19 and 22 respectively)
is inserted to cooperate with a threaded hole in the region of the first aligning surfaces P1
and P2.

A second contact portion 23 incorporates an inner groove with laterally situated second
contact surfaces 24 for guided cooperation with an aligning spigot 25 which is firmly
fitted in a oriented manner in, and protrudes from, the engine block. It should be noted
that the second contact portion 23 does not abut directly against any aligning surface on
the engine block but is only indirectly aligned via the spigot 25.

The housing 14 further incorporates a first fastening portion 26 and a second fastening
portion 27 which are likewise not intended to abut directly against any aligning surface on
the engine block. These fastening lugs are fastened instead at a distance therefrom by
means, for example, of a positional error compensating fastening device 35 not further
described here such as, for example, that referred to in the applicant's Swedish patent no.
501 741. These fastenings serve to fix and stabilise the housing 14 relative to the engine
block after alignment of the contact portions relative to corresponding aligning surfaces
or spigots. As may be seen in the diagram, the fastening lugs protrude considerably
sideways as viewed from the bearing abutment 15 of the output shaft. This arrangement
results in stable fixing to the engine block.
Fig. 3 shows the housing 14 with the bearing abutment 15 as viewed from behind and partly concealed by the boss of the oil outlet 16. It further shows not only fixing portions 26 and 27 but also a flange 29 for connecting a casing for a power turbine to the housing section 14. The diagram shows on the right of the housing section 14 the first and second contact portions 17, 20 and 23, and in the case of this latter the delineations of the second contact surfaces 24 are hinted at by broken lines. In this version the groove formed in the second contact portion 23 is open forwards but is ended by a transverse wall 24.

Fig. 4 is a sectional view of the housing section 14 including inter alia the hydraulic coupling 9 and the output shaft 10. The bearing abutment 15 is intended to serve as a guide element for the housing section 14 by means of the peripheral circular cylindrical surface 28. This guide surface 28 is arranged to cooperate with a guide hole 31 formed in a transmission plate 30 which is itself orientedly fastened by means of guide pins (not depicted) to the engine block in the latter’s rear region, i.e. in the direction towards the engine’s transmission. Also visible in this diagram is a gearwheel 32 which is mounted on the unit’s output shaft 10 and forms part of the second gear set, corresponding to that denoted by ref. 11 in Fig. 1.

In the design depicted, the output shaft and, in particular, this gearwheel 32 are well guided by a rolling bearing 33 inserted in the bearing abutment, with the bearing adjacent to the gearwheel. This illustrates the bearing abutment’s dual function not only as a bearing seat but also as a guide element for the turbocompound unit. This dual function provides reliable and easy guidance of the housing and, in particular, of the shaft 10 and its gearwheel 32, resulting in reliable engagement with the intermediate gear (not depicted) with which the gearwheel has to cooperate. With advantage, this intermediate gear is supported by a pivot pin fastened to the transmission plate.

Ref. 34 denotes a first sealing portion inserted between the bearing abutment 15 and a drilled hole in the transmission plate which is somewhat larger than the guide hole 31. This results in sealing in the axial direction between the bearing abutment and the transmission plate. Also present is a second sealing portion 35 arranged to seal between the housing 14 and the transmission plate in a region radially outside the bearing abutment. In this embodiment the sealing portions are separate from one another, which
entails the provision of corresponding separate seal seats. Ref. 14” denotes the previously mentioned cover which in this diagram is fitted to the surface 14’ of the housing section 14.

5 Fitting the turbocompound unit to the combustion engine entails placing the unit’s housing 14, 14’ against the engine block with the contact surfaces 17 and 20 abutting against corresponding aligning surfaces P1 and P2 on the engine block (see Fig. 3). Thereafter, the housing 14, 14’ is moved in the direction of the arrow A corresponding to leftward movement in Figs. 1 and 4 and movement upwards from the plane of the paper in Fig. 2. The spigot 25 is thus guided in between the second contact surfaces 24 in the groove in the second contact portion 23, and the guide surface 28 of the bearing abutment 15 is guided into the guide hole 31 in the transmission plate 30. When a position of sufficient insertion has been reached, the screws are tightened inside the first contact portions 17 and 20, followed by tightening of the fastening elements which pass through the fastening portions 26 and 27. The result is very good alignment of the turbocompound unit relative to the gearwheels of the second gear set. Such is the case irrespective of whether the engine is subject to powerful vibrations or whether deflections due to deformations occur in the region of the flywheel casing. However, the distance and hence the gap between the housing and transmission plate will be somewhat different for different engines. This situation is of no significance for the service life of the gearwheels incorporated but, as indicated above, sealing between the housing and the transmission plate must be possible even where different gap widths occur.

It may be mentioned in this context that the suspension points for the engine and the associated transmission in today’s vehicles are situated further apart than in previous installations. This fact has made the region of the flywheel casing increasingly unsuitable for fastening the turbocompound unit, owing to the increased deformations arising from this suspension principle.

30 The parts depicted in Fig. 5a relate to a housing 14 with the bearing abutment 15 before fitting into the guide hole 31 of the transmission plate 30. A sealing ring 37 with L-shaped cross-section is placed on the bearing abutment 15 and has a first sealing portion 38 abutting against the bearing abutment and a second sealing portion 39 abutting against
a contact surface 41 which runs substantially radially on the housing 14. As hinted in Fig. 5a, the length of the abutment is increased so that guidance cooperation with the guide hole 31 is achieved before the more closely adjacent surfaces of the housing and the transmission plate come into mutual proximity. Damage to the sealing device during fitting is thus prevented. This may be accentuated by further axial lengthening of the bearing abutment 15. In Fig. 5b the housing 14 has reached its operating position in which the first sealing portion seals both axially and radially in the drilled hole 36 (Fig. 5a) by means of an obliquely directed sealing lip. The second sealing portion 39 seals by means of an outer annular thickening between the housing surface 41 and the transmission plate.

The annular thickening is increased so that it can seal even varying gaps between the surface 41 and the transmission plate 30.

The invention may be varied within the scopes of the claims set out below. The sealing device may thus be an integrated sealing ring with dual functions, or separate ring seals. The cross-section may also be modified and differ from the embodiment depicted. The seal material is an elastic material of a conventional kind suitable for seals of the kind here concerned.
Patent claims:

1. A sealing device (34,35;37) for a housing (14) for a turbocompound unit (5) which incorporates an output shaft (10) which is arranged to transmit power from the power turbine to a flywheel of the combustion engine, **characterised** by
   - a first sealing portion (34;38) for placing radially round and in sealing cooperation with a shell surface for a protruding bearing abutment (15) which is arranged for a bearing (33) for the output shaft (10) of the turbocompound unit (5) and which is intended for guidance cooperation with a transmission plate (30) fastened to the engine block (2), whereby the first sealing portion is also adapted to sealing radially outwards against a region of the transmission plate, and
   - a second sealing portion (35;39) for placing radially outside the bearing abutment (15) and adapted to sealing axially between, and catering for variation of the axial distance between, the housing (14) and the transmission plate (30).

2. A device according to claim 1, **characterised** in that the first sealing portion (38) and the second sealing portion (39) are integrated in a sealing ring with substantially L-shaped cross-section.

3. A device according to claim 1 or 2, **characterised** in that the first sealing portion (38) has a sealing lip which is directed obliquely radially outwards and away from the second sealing portion (39) and is for sealing cooperation with not only a surface running radially but also a surface running axially on the transmission plate.

4. A device according to claim 1, 2 or 3, **characterised** in that the second sealing portion (39) takes the form of an annular thickening arranged radially furthest outwards which is connected to the first sealing portion by a thinner web portion (40).

5. A device according to claim 1, **characterised** in that the first sealing portion (38) and a second sealing portion (39) are separate sealing rings.
6. A combustion engine, characterised in that its engine block is equipped with aligning surfaces for aligned fastening of a turbocompound unit and that it includes a sealing device according to any one of claims 1-5.