Abstract:

The invention pertains to a system comprising a gearbox, an oil pump, and an electronic control device for control of the displacement of the oil pump and the shift event of the gearbox. The invention is centered around the control of the displacement of the oil pump and the shift event of the gearbox. The invention is particularly directed to a method for control of a flow of transmission oil in such a system.

Title:

SYSTEM FOR LUBRICATION AND COOLING OF A GEARBOX AND METHOD FOR CONTROL OF A FLOW OF TRANSMISSION OIL IN SUCH A SYSTEM
FIELD OF THE INVENTION AND PRIOR ART

The present invention pertains to a system according to the preamble to claim 1 for lubrication and cooling of a gearbox equipped with synchromeshes, and a method for control of a flow of transmission oil in such a system. The invention also pertains to a computer program and a computer program product comprising computer program code for the implementation of a method according to the invention, and an electronic control device.

In order to reduce the wear and thus extend the life of different components in a gearbox, these components are lubricated with transmission oil. The oil system in a gearbox in a motor vehicle usually comprises an oil pump in the form of a displacement pump of rotor type, connected to a side shaft in the gearbox in order to be operated by the same, so that the oil pump's pump rotor is operated to rotate with the same rotation speed as the side shaft. From an oil sump at the bottom of the gearbox, transmission oil is sucked up by the oil pump in order to be fed through oil channels in the gearbox, following which the transmission oil trickles back down into the oil sump. Certain types of gearboxes are equipped with synchromeshes, becoming activated in connection with a change of gear in the gearbox to achieve a synchronous rotation speed of two components, which
become rotatably engaged with each through the shifting operation. These synchromeshes emit a friction heat when they are active, and need to be cooled down to reduce wear and thus to extend the life of the synchromeshes. The required cooling of the synchromeshes occurs with the help of the circulating transmission oil, brought to flow past the synchromeshes to lead heat away from these. In order to improve the cooling ability of the transmission oil, the transmission oil may be led through an oil cooler before it is led into the oil channels in the gearbox.

OBJECTIVE OF THE INVENTION

The objective of the present invention is to achieve a new and advantageous way of controlling the flow of transmission oil in a gearbox equipped with synchromeshes.

SUMMARY OF THE INVENTION

According to the present invention, said objective is achieved with a system having the characteristics defined in claim 1.

The system according to the invention comprises:
- an oil conduit, which is connected to oil channels in the gearbox to enable the transmission oil to be fed from the oil conduit to said oil channels for lubrication and cooling of bearings and synchromeshes inside the gearbox,
- an oil pump with variable displacement, for generation of a flow of transmission oil through the oil conduit, in the direction towards said oil channels, so that the oil pump is connected to and arranged to be operated by a side shaft in the gearbox,
- a cooling device connected to the oil conduit for cooling of the transmission oil,
- a manoeuvring device for control of the displacement of the oil pump, and
- an electronic control device, for control of the manoeuvring device.

The electronic control device is arranged to control the manoeuvring device to temporarily increase the displacement of the oil pump from a normal displacement level to an increased displacement level, when it obtains information indicating that a shift event for change of gears in the gearbox has been initiated or is intended to be initiated. The displacement search in the oil pump leads to a temporarily increased volume flow of transmission oil in the oil conduit and in said oil channels during the shift event, so that a temporarily elevated cooling effect of the transmission oil flowing through the oil channels is obtained during the shift event. The increased volume flow of transmission oil during the shift event entails that the transmission oil's ability to deflect friction heat from the synchromeshes inside the gearbox increases, which in turn provides an improved cooling of the synchromeshes, and thus an extended service life of these.

According to one embodiment of the invention, the electronic control device is arranged to control the manoeuvring device at said temporary displacement increase, to set the displacement of the oil pump at a volume corresponding to a predetermined fixed value. Thus, the solution according to the invention may be implemented in a relatively easy manner.
According to another embodiment of the invention, the electronic control device is arranged to control the manoeuvring device at said temporary displacement search, so that it sets the displacement of the oil pump at a volume corresponding to a set value calculated by the electronic control device, based on a predetermined calculation model. Thus, the displacement of the oil pump may be controlled based on criteria determined in advance, so that the volume flow of transmission oil during different shift events is adapted, depending on the cooling effect required for the respective shift events.

Other favourable features of the system according to the invention are set out in the non-independent claims and the description below.

The invention also pertains to a method with the characteristics defined in claim 7, for control of a flow of transmission oil in a system for lubrication and cooling of a gearbox equipped with synchromeshes.

Other advantageous features of the method according to the invention are set out in the non-independent claims and the description below.

The invention also pertains to a computer program with the characteristics defined in claim 13, a computer program product with the characteristics defined in claim 14 and an electronic control device with the characteristics defined in claim 15.
The invention is described below with the help of example embodiments, with reference to the enclosed drawings. Shown in:

Fig. 1 is a diagram of a system according to one embodiment of the present invention,

Fig. 2 is a diagram of an electronic control device for the implementation of a method according to the invention, and

Fig. 3 is a flow chart illustrating a method according to one embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS ACCORDING TO THE INVENTION

Fig. 1 illustrates very schematically a gearbox 1 for a motor vehicle. The gearbox 1 is equipped with synchromeshes 2, 2', 2" of a prior art type, controlled by an electronic control device 3.

The gearbox 1 may e.g. comprise a number of synchromeshes 2, each of which is arranged for connection of a rotating shaft in the gearbox 1 with a cogwheel, which is rotatably supported on the given shaft. When such a synchromesh 2 is activated by the control device 3 in connection with a shift event for change of gears in the gearbox 1, the synchromesh 2 is arranged to achieve a synchronous rotation speed of a rotating shaft and a cogwheel rotatably supported on the shaft, before these are
brought into a rotatable engagement with each other. Said shaft may e.g. consist of an input shaft, a side shaft or a main shaft of the gearbox 1.

The gearbox 1 may also comprise a synchromesh 2', which is arranged for mutual connection of an input shaft and a main shaft of the gearbox when, in connection with a change of gears in the gearbox, a direct connection between these shafts is to be set up. When such a synchromesh 2' is activated by the control device 3 in connection with a shift event for change of gears in the gearbox 1, the synchromesh 2' is arranged to achieve a synchronous rotation speed of the input shaft and the main shaft, before these are brought into a rotatable engagement with each other.

In cases where the gearbox 1 comprises a range gear unit with a planetary gear, the gearbox 1 may also comprise a synchromesh 2'', which is arranged to act on a ring wheel of said planetary gear in connection with a change of gears between a low range gear and a high range gear in the range gear unit. In the low range gear, the ring wheel is rotatably connected with a first coupling element, which is rotatably connected with the gearbox house of the gearbox, and in the high range gear the ring wheel is rotatably connected with a second coupling element, which is rotatably connected with the main shaft of the gearbox. When this synchromesh 2'' is activated by the control device 3 in connection with a change of gears from a low range gear to a high range gear in the range gear unit, the synchromesh 2'' is arranged to achieve a synchronous rotation speed of the ring wheel and said second coupling element, before these are
brought into a rotatable engagement with each other. When this synchromesh 2" is activated by the control device 3 in connection with a change of gears from a high range gear to a low range gear in the range gear unit, the synchromesh 2" is arranged to brake the ring wheel to a standstill, before the ring wheel is brought into a rotatable engagement with said first coupling element.

The gearbox 1 has an input shaft 4 which, via a coupling device 5, may be connected with a drive shaft 6 of a drive engine 7. With the help of the coupling device 5, the input shaft 4 of the gearbox may be brought into a transmission connection with, as well as disconnected from, said drive shaft 6. The drive engine 7 may e.g. consist of a combustion engine.

Fig. 1 illustrates a system 10 for lubrication and cooling of the gearbox 1. This system 10 comprises an oil conduit 11, which is connected to oil channels 12 in the gearbox to enable the transmission oil to be fed from the oil conduit 11 to said oil channels 12, for lubrication and cooling of bearings and synchromeshs 2, 2', 2" inside the gearbox 1. The system 10 also comprises an oil pump 13, for generation of a flow of transmission oil through the oil conduit 11 in the direction towards said oil channels 12. A cooling device 14 in the form of conventional oil cooler is connected to the oil conduit 11 for cooling of the transmission oil. The cooling device 14 is connected with the oil conduit 11, between the oil pump 13 and said oil channels 12. A thermostat 15 is arranged inside the oil conduit 11, between the oil pump 13 and the cooling device 14. Depending on the temperature of the transmission oil flowing
inside the oil conduit 11, the thermostat 15 leads the transmission oil to the cooling device 14, to be cooled here before the transmission oil is led further along to the oil channels 12 in the gearbox, or directly to these oil channels 12 via a bypass conduit 16 without passing through the cooling device 14.

An oil filter 17 of conventional type is arranged inside the oil conduit 11, between the oil pump 13 and the thermostat 15, for filtration of the transmission oil flowing through the oil conduit 11. An oil sump 18 is arranged at the bottom of the gearbox 1. From this oil sump 18, transmission oil is sucked up by the oil pump 13 in order to be fed through the oil conduit 11. After its passage through the oil channels 12 in the gearbox 1, the transmission oil trickles back down into the oil sump 18.

The oil pump 13 comprises a pump rotor which in a conventional manner is connected to a side shaft 21 in the gearbox 1, in order to be operated by the latter. The pump rotor will thus rotate with an engine speed dependent on the engine speed of the side shaft 21. The oil pump 13 is a pump with a variable displacement, and comprises a moveable setting element (not displayed) which may be brought into different positions, so that the oil pump's displacement varies depending on the position of the setting element.

The oil pump 13 is preferably a wing pump with a variable displacement. In a wing pump with a variable displacement, the pump rotor is eccentrically arranged inside an annular setting element, which may be brought into different positions in relation to the pump rotor, for regulation of the wing pump's displacement. The annular setting element may be shiftably
arranged, such as illustrated in US 2012/0093672 A1, or pivotally arranged, such as illustrated in US 6763797 B1.

The system 10 comprises a manoeuvring device 19 for control of the displacement of the oil pump 13 and an electronic control device 20 for control of the manoeuvring device. The manoeuvring device 19 may comprise a hydraulic or a pneumatic cylinder for control of the position of the oil pump's setting element, with the electronic control device 20 being arranged to control the supply of hydraulic liquid or pressurised air to said cylinder. The manoeuvring device 19 could, alternatively, comprise an electric engine for control of the position of the oil pump's setting element, with the electronic control device 20 being arranged to control the supply of electric power to said engine.

The electronic control device 20 is arranged to receive information, e.g. from the control device 3, indicating when a shift event for change of gears in the gearbox 1 has been initiated, or is intended to be initiated.

In a normal case, when the electronic control device 20 has not received any information indicating that a shift event for change of gears in the gearbox 1 has been initiated or is intended to be initiated, the electronic control device 20 is arranged to control the manoeuvring device 19 to maintain the displacement of the oil pump 13 at a level, which is herein referred to as the normal displacement level.
When the electronic control device 20 obtains information from the control device 3, indicating that a shift event for change of gears in the gearbox 1 has been initiated or is intended to be initiated, the electronic control device 20 is arranged to control the manoeuvring device 19 to achieve a temporary displacement search in the oil pump 13, so that the oil pump's displacement temporarily increases from the normal displacement level to an increased displacement level, in order thus to achieve a temporarily increased volume flow of transmission oil in the oil conduit 11 and in said oil channels 12 during the shift event, and thus a temporarily elevated cooling effect of the transmission oil flowing through the oil channels 12. Thereby an improved cooling of the synchromeshes 2, 2', 2" is obtained during the shift event.

According to a first alternative, the electronic control device 20 is arranged to control the manoeuvring device 19, at said temporary displacement search, so that it sets the displacement of the oil pump 13 at a volume corresponding to a predetermined fixed value, which preferably corresponds to the maximum displacement of the oil pump 13.

According to a second alternative, the electronic control device 20 is arranged to control the manoeuvring device 19, at said temporary displacement search, so that its sets the displacement of the oil pump 13 at a volume corresponding to a set value \( V_{\text{calc}} \), calculated by the electronic control device 20 based on a predetermined calculation model. The electronic control device 20 may e.g. be arranged to determine said set value \( V_{\text{calc}} \) according to the following formula:
\[ V_{\text{caic}} = \min \left( \max \left( \frac{\max \left( N_{\text{eng}} \left| 1 - \frac{R_{\text{sp}}}{R_{\text{mp}}} \right| \frac{N_{\text{eng}}}{R_{\text{sn}} \cdot R_{\text{mn}} - N_{\text{main}}} \right) - N_{\text{main}}}{D_{\text{ref}}} \right), V_{\text{max}} \right), V_{\text{norm}} \right) \]

where:

- \( V_{\text{caic}} \) is the calculated set value for displacement of the oil pump 13,
- \( N_{\text{eng}} \) is the engine speed of the drive engine's drive shaft 6,
- \( N_{\text{main}} \) is the engine speed of the main shaft of the gearbox,
- \( V_{\text{max}} \) is the maximum displacement of the oil pump 13,
- \( V_{\text{norm}} \) is the normal displacement of the oil pump 13,
- \( R_{\text{sn}} \) is the gear ratio of a split gear unit comprised in the gearbox for the new gear intended to be engaged during the given shift event,
- \( R_{\text{sp}} \) is the split gear unit's gear ratio for the most recently engaged gear,
- \( R_{\text{mn}} \) is the gear ratio of the main gear unit of the gearbox for the new gear intended to be engaged during the given shift event, and
- \( D_{\text{ref}} \) is a predetermined reference engine speed difference, which may be set at e.g. 1,000 rpm.

After the displacement search as specified above has been executed, the electronic control device 20 is arranged to control the manoeuvring device 19 to reduce the displacement of the oil pump 13 from the increased displacement level to the normal displacement level, when the electronic control device 20 has determined that a predetermined condition is met. According to a first alternative, the electronic control device 20 is arranged to control the manoeuvring device 19 to reduce the displacement of
the oil pump 13 from the increased displacement level to the normal displacement level, when the electronic control device 20 has determined that a given period of time has elapsed since the point in time when the electronic control device 20 initiated the temporary displacement increase. According to a second alternative, the electronic control device 20 is arranged to control the manoeuvring device 19 to reduce the displacement of the oil pump 13 from the increased displacement level to the normal displacement level, when the electronic control device 20 has determined that the current shift event has been completed, e.g. by having received information indicating this from the control device 3.

The electronic control device 20 described above may be implemented through one single electronic control device in the motor vehicle, as illustrated in Fig. 1. The electronic control device 20 could, however, be implemented through two or more mutually collaborating electronic control devices in the motor vehicle.

Fig. 3 shows a flow chart illustrating an embodiment of a method according to the present invention, for the control of a flow of transmission oil in a system 10 of the type described above. In a first step S1, the electronic control device 20 determines whether a shift event for change of gears in the gearbox 1 has been initiated. If, in step S1, the electronic control device 20 in step S1 has determined that no shift event has been initiated, the step S1 is repeated after a certain time delay. If, in step S1, the electronic control device 20 has determined that a shift event has been initiated, the electronic control device 20 calculates, in a
subsequent step S2, a set value $v_{calc}$ for an increased displacement of the oil pump 13. In a third step S3, the manoeuvring device 19 is controlled by the electronic control device 20 to set the displacement of the oil pump 13 at a volume corresponding to said set value $V_{calc}$, so that the displacement of the oil pump 13 increases from a normal displacement level to an increased displacement level. In a fourth step S4, the electronic control device 20 determines whether the shift event has been completed. If, in step S4, the electronic control device 20 has determined that the shift event has not been completed, the step is repeated after a certain time delay. If, in step S4, the electronic control device 20 in step S4 has determined that the shift event has been completed, the electronic control device 20 controls the manoeuvring device 19, in a subsequent fifth step S5, so that it reduces the displacement of the oil pump 13 from the increased displacement level to the normal displacement level. Subsequently, the first step S1 mentioned above is repeated.

A computer program code, for the implementation of a method according to the invention, is suitably included in a computer program, loadable into the internal memory of a computer, such as the internal memory of an electronic control device of a motor vehicle. Such a computer program is suitably provided via a computer program product comprising a data storage medium readable by an electronic control device, which data storage medium has the computer program stored thereon. Said data storage medium is e.g. an optical data storage medium in the form of a CD-ROM, a DVD, etc., a magnetic data storage medium in the form of a hard disk drive, a diskette, a cassette, etc., or a
Flash memory or a ROM, PROM, EPROM or EEPROM type memory.

Fig. 2 illustrates very schematically an electronic control device 30 comprising an execution means 31, such as a central processor unit (CPU), for the execution of a computer software. The execution means 31 communicates with a memory 32, e.g. a RAM memory, via a data bus 33. The control device 30 also comprises a data storage medium 34, e.g. in the form of a Flash memory or a ROM, PROM, EPROM or EEPROM type memory. The execution means 31 communicates with the data storage means 34 via the data bus 33. A computer program, comprising computer program code for the implementation of a method according to the invention, e.g. in accordance with the embodiment illustrated in Fig. 3, is stored in the data storage medium 34.

The system and the method according to the invention are specifically designed to be used in a heavy goods vehicle, such as a bus, a tractor or a truck.

The invention is not limited in any way to the embodiments described above, but numerous possible modifications thereof should be obvious to a person skilled in the area, without such person departing from the spirit of the invention as defined by the appended claims.
CLAIMS

1. System for lubrication and cooling of a gearbox (1) equipped with synchromeshes (2, 2', 2''), the system (10) comprising:

- an oil conduit (11), connected to oil channels (12) in the gearbox to enable the transmission oil to be fed from the oil conduit (11) to said oil channels (12) for lubrication and cooling of bearings and synchromeshes (2, 2', 2'') inside the gearbox (1),

- an oil pump (13) for generation of a flow of transmission oil through the oil conduit (11) in the direction towards said oil channels (12), so that the oil pump (13) is connected to and arranged to be operated by a side shaft (21) in the gearbox (1), and

- a cooling device (14) connected to the oil conduit (11) for cooling of the gearbox,

characterised in that:

- the oil pump (13) is a pump with a variable displacement,
- the system (10) comprises a manoeuvring device (19) for control of displacement of the oil pump (13), and an electronic control device (20) for control of a manoeuvring device (19), and

- the electronic control device (20), when it obtains information indicating that a shift event for change of gears in the gearbox (1) has been initiated or is intended to be initiated, is arranged to control the manoeuvring device (19) to temporarily increase the displacement of the oil pump (13) from a normal displacement level to an increased displacement level, in order to thus achieve a temporarily increased volume flow of transmission oil in the oil conduit (11) and in said oil channels.
(12) during the shift event and thus a temporarily increased cooling effect of the transmission oil flowing through the oil channels (12).

5 2. System according to claim 1, characterised in that the electronic control device (20) is arranged to control the manoeuvring device (19), at said temporary displacement search, to set the displacement of the oil pump (13) at a volume corresponding to a predetermined fixed value.

3. System according to claim 2, characterised in that said fixed value corresponds to the maximum displacement of the oil pump (13).

4. System according to claim 1, characterised in that:
   - the electronic control device (20) is arranged to calculate a set value \( V_{calc} \) for the oil pump's temporarily increased displacement, based on a predetermined calculation model, and
   - the electronic control device (20) is arranged to control the manoeuvring device (19), at said temporary displacement search, to set the displacement of the oil pump (13) at a volume that corresponds to said calculated set value \( V_{calc} \).

5. System according to any of claims 1-4, characterised in that the electronic control device (20) is arranged to control the manoeuvring device (19) to reduce the displacement of the oil pump (13) from the increased displacement level to the normal displacement level, when the electronic control device (20) has determined that a given period of time has elapsed since
the point in time when the electronic control device (20) initiated said temporary displacement search.

6. System according to any of claims 1-4, characterised in that the electronic control device (20) is arranged to control the manoeuvring device (19) to reduce the displacement of the oil pump (13) from the increased displacement level to the normal displacement level, when the electronic control device (20) has determined that the shift event has been completed.

7. Method for control of a flow of transmission oil in a system (10) for lubrication and cooling of a gearbox (1) equipped with synchromeshes (2, 2', 2") wherein the system (10) comprises:
   - an oil conduit (11), which is connected to oil channels (12) in the gearbox to enable the transmission oil to be fed from the oil conduit (11) to said oil channels (12) for lubrication and cooling of bearings and synchromeshes (2, 2', 2") inside the gearbox (1),
   - an oil pump (13), for generation of a flow of transmission oil through the oil conduit (11) in the direction towards said oil channels (12), wherein the oil pump (13) is a pump with a variable displacement and is connected to and arranged to be operated by a side shaft (21) in the gearbox (1),
   - a manoeuvring device (19), for control of the displacement of the oil pump (13),
   - an electronic control device (20), for control of the manoeuvring device (19), and
   - a cooling device (14), connected to the oil conduit (11) for cooling of the gearbox,
wherein the method is characterised in that the electronic control device (20), when it receives information indicating that a shift event for change of gears in the gearbox (1) has been initiated, or is intended to be initiated, controls the manoeuvring device (19) to temporarily increase the displacement of the oil pump (13) from a normal displacement level to an increased displacement level, in order thus to achieve a temporarily increased volume flow of transmission oil in the oil conduit (11) and in said oil channels (12) during the shift event, and thus a temporarily elevated cooling effect of the transmission oil flowing through the oil channels (12).

8. Method according to claim 7, characterised in that the electronic control device (20) controls the manoeuvring device (19), at said temporary displacement search, to set the displacement of the oil pump (13) at a volume corresponding to a predetermined fixed value.

9. Method according to claim 8, characterised in that said fixed value corresponds to the maximum displacement of the oil pump (13).

10. Method according to claim 7, characterised in that:
- the electronic control device (20) calculates a set value \( V_{calc} \) for the oil pump's temporarily increased displacement, based on a predetermined calculation model, and
- the electronic control device (20) controls the manoeuvring device (19), at said temporary displacement search, to set the displacement of the oil pump (13) at a volume corresponding to said calculated set value \( V_{calc} \).
11. Method according to any of claims 7-10, characterised in that the electronic control device (20) controls the manoeuvring device (19) to reduce the displacement of the oil pump (13) from the increased displacement level to the normal displacement level, when the electronic control device (20) has determined that a given period of time has elapsed since the point in time, when the electronic control device (20) initiated said temporary displacement search.

12. Method according to any of claims 7-10, characterised in that the electronic control device (20) controls the manoeuvring device (19) to reduce the displacement of the oil pump (13) from the increased displacement level to the normal displacement level, when the electronic control device (20) has determined that the shift event has been completed.

13. Computer program, comprising computer program code to bring a computer to implement a method according to any of claims 7-12 when the computer program code is executed in the computer.

14. Computer program product, comprising a data storage medium which is readable by a computer, wherein the computer program code of a computer program according to claim 13 is stored on the data storage medium.

15. Electronic control device in a motor vehicle, comprising an execution means (31), a memory (32) connected to the execution means and a data storage medium (34) connected
to the execution means, wherein the computer program code in a computer program according to claim 13 is stored on said data storage medium (34).
Fig 2

Has a shifting event been initiated? \( S_1 \)

YES

Calculate \( V_{calc} \) \( S_2 \)

Pass to increased displacement level \( S_3 \)

NO

Has the shifting event been completed? \( S_4 \)

NO

YES

Revert to normal displacement level \( S_5 \)

Fig 3
**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/SE2014/051049

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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: F01M, F16H, F16N

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>A</td>
<td>DE 102008063608 A1 (SCANIA CV AB), 16 July 2009 (2009-07-16); abstract; figures</td>
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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

"I" 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

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"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

09-12-2014

Date of mailing of the international search report

09-12-2014

Name and mailing address of the ISA/SE

Patents- och registreringsverket

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Form PCT/ISA/210 (second sheet) (July 2009)
### DOCUMENTS CONSIDERED TO BE RELEVANT

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International Patent Classification (IPC)

F16H 57/04 (2010.01)
## INTERNATIONAL SEARCH REPORT

### Information on patent family members

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