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Fig. 1

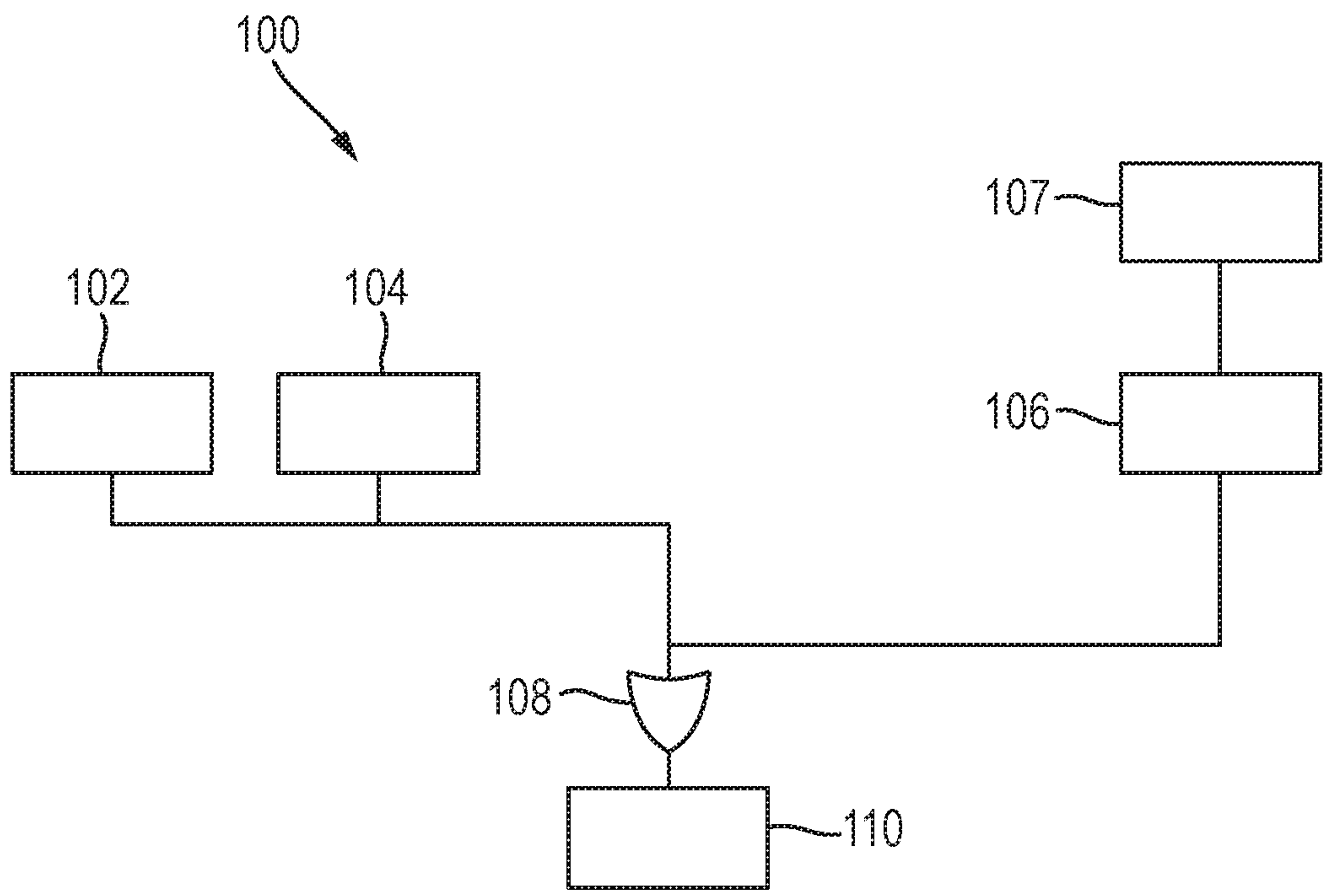


Fig. 2

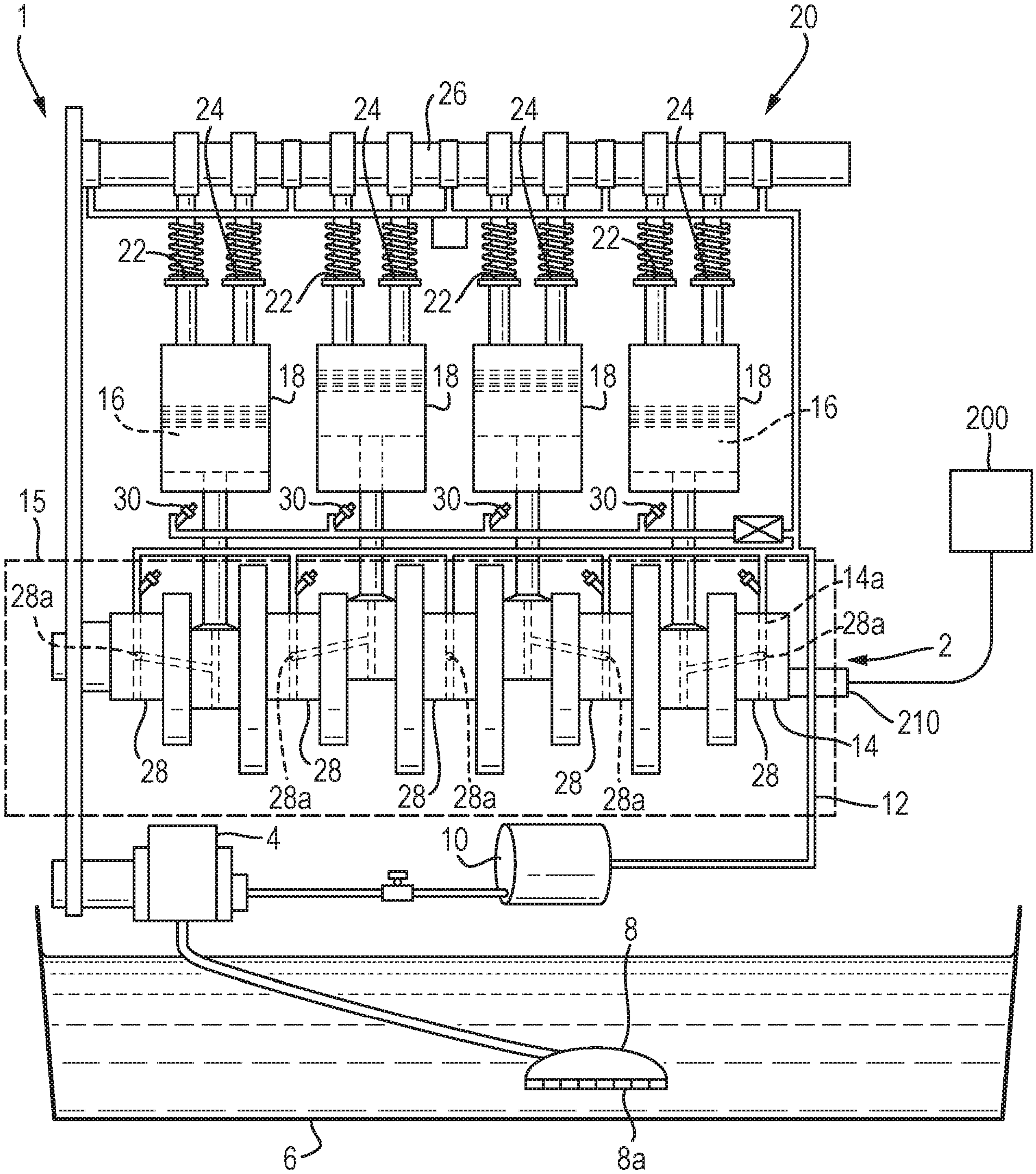

1
20
26
24
24
24
24
22
22
22
22
18
18
18
18
16
16
200
15
30
30
30
30
14a
28a
28a
2
210
14
28
28
28
28
28
28a
28a
28a
12
4
10
8
6
8a

Fig. 3

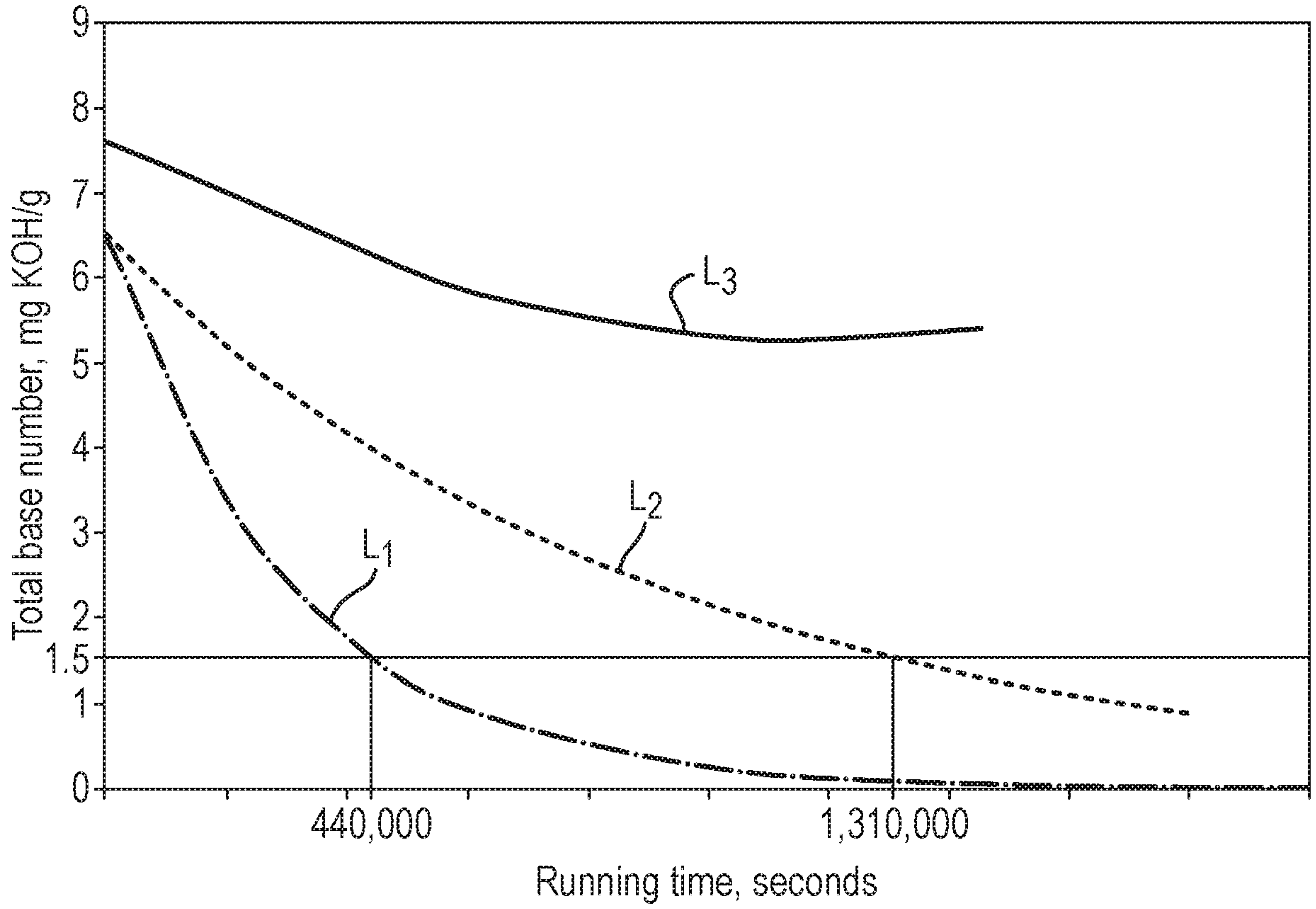

9
8
7
6
5
4
3
2
1.5
1
0
Total base number, mg KOH/g
L3
L2
L1
440,000
1,310,000
Running time, seconds

Fig. 4

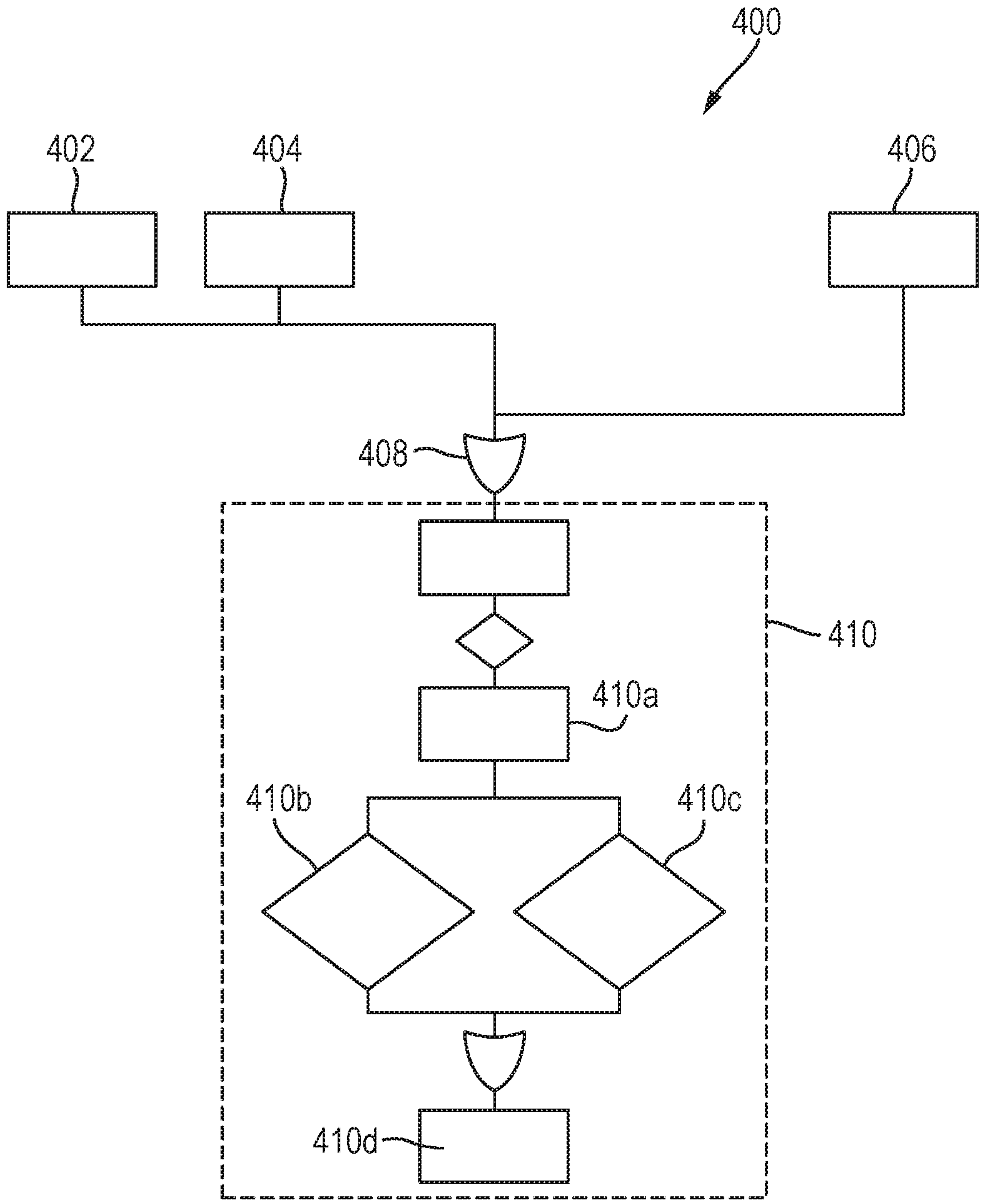
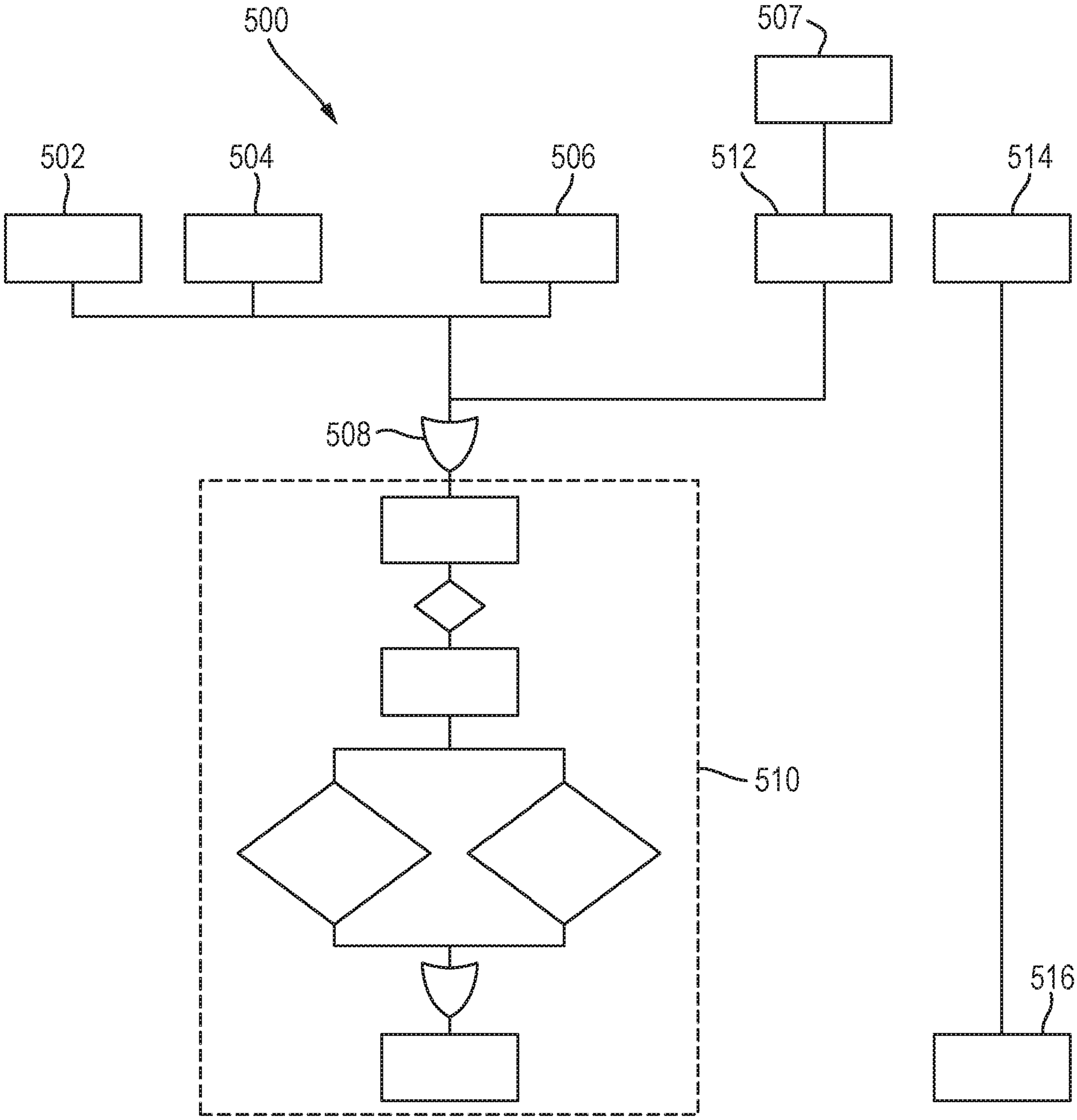


Fig. 5



A method and system for determining an oil change interval

Technical Field

The present disclosure relates to a method and system for determining an oil change interval and is particularly, although not exclusively, concerned with a method for determining an oil change interval that allows the frequency of oil changes to be reduced.

Background

Engine oil within a motor vehicle may typically be changed after the vehicle has travelled a predetermined distance or has been operating for a predetermined period of time since a previous oil change. However, it is desirable for the engine oil to be replaced if the oil quality, e.g. the concentration of one or more additives in the oil, is reduced to below a threshold level before the predetermined distance or predetermined period of time has been reached.

With reference to Figure 1, a previously proposed oil life monitor applies a method 100, e.g. an algorithm, in order to determine whether an oil change is due. In a first block 102 of the method, it is determined whether the motor vehicle has travelled a distance greater than or equal to the predetermined distance since the previous oil change. In a second block 104 of the method, it is determined whether the motor vehicle has been operating for a period of time greater than or equal to the predetermined period of time since the previous oil change.

In a third block 106, the quality of the oil is estimated, and it is determined whether the oil quality is less than or equal to the predetermined quality. As depicted in Figure 1, existing oil change methods for motor vehicles typically refer to engine revolution information 107 provided by an engine revolution counter, and predict or estimate how much the oil quality is expected to have deteriorated based on the number of engine revolutions performed since the previous oil change.

A fourth block 108, comprises an “OR” gate, which receives inputs from the first, second and third blocks 102, 104, 106. If any of the determinations made in the first, second and third blocks 102, 104, 106 are positive, the method 100 proceeds to a fifth block 110, in which the oil life monitor delivers an oil change message, e.g. informing a driver of the motor vehicle that the oil change interval has been reached.

Estimates of oil quality made by referring to engine revolution information are typically overly conservative for most drivers and most drive cycles performed by the motor vehicle. Hence, drivers are often alerted to change their oil based on the estimated oil quality reduction before the oil has reached its useful life. Furthermore, drivers are often alerted to change their oil based on the estimated oil quality reduction before the predetermined distance or predetermined time period since the previous oil change has been reached.

An improved method of determining the quality of oil is therefore desirable to enable users of motor vehicles to continue using their vehicle for longer without being alerted to change their oil, thereby reducing the cost of maintaining the motor vehicle and the environmental impact of frequently replacing engine oil.

Statements of Invention

According to an aspect of the present disclosure, there is provided, a method for determining an oil change interval comprising: determining an oil quality of oil within an oil system of a motor vehicle, wherein the oil quality is determined as a function of a ratio of engine torque to peak engine torque; determining whether an oil change interval has been reached based on the oil quality. For example, if the oil quality is less than the threshold value a driver of the motor may be alerted to change the engine oil.

The oil quality may be determined as a function of oil temperature and engine torque.

The function of engine torque may be an exponential decay function. The exponential decay constant may be based on the engine torque. The exponential decay constant may be based on a ratio of engine torque or average engine torque, e.g. over a drive cycle, to peak engine torque. Optionally, the exponential decay constant may be based on oil temperature and engine torque (or engine torque ratio).

The oil quality may correspond to a concentration of an additive within the oil. Such as base additives. For example oil quality may correspond to a Total Base Number (TBN) of the oil.

The method may comprise determining at least one of a distance travelled by the motor vehicle and an operating time of the motor vehicle since a previous oil change. The step of determining whether the oil change interval has been reached may be performed based on the distance travelled and/or operating time.

The method may further comprise determining a further oil quality. The further oil quality may be determined according to a function of the number of revolutions performed by an engine of the motor vehicle. The step of determining whether the oil change interval has been reached may be performed based on the further oil quality.

The method may further comprise alerting a user, e.g. the driver of the motor vehicle, when the oil change interval is reached. For example, if it has been determined based on any of the oil quality, the further oil quality, a distance travelled by the motor vehicle or an operating time of the oil system that the oil change interval has been reached.

The method may further comprise determining or predicting a quantity of oil within the oil system of the motor vehicle. The method may further comprise alerting the user if the quantity of oil may be below a threshold quantity.

The quantity of oil within the oil system may be determined according to a number of revolutions performed by an engine of the motor vehicle.

According to another aspect of the present disclosure, there is provided an oil system for a motor vehicle, the system comprising and controller having one or more modules configured to: determine an oil quality of oil within an oil system of a motor vehicle, wherein the oil quality is determined as a function of a ratio of engine torque to peak engine torque; and determine whether an oil change interval has been reached based on the determined oil quality.

The controller may comprise one or more further modules configured to determine at least one of a distance travelled by the motor vehicle and an operating time of the motor vehicle, e.g. distance travelled and/or operating time of the motor vehicle, since a previous oil change.

16 11 18

The controller may comprise one or more further modules configured to determine whether the oil change interval has been reached based on the distance travelled and/or operating time.

The controller may comprise one or more further modules configured to determine whether the oil change interval has been reached based on oil quality, distance travelled and/or operating time. The controller may comprise one or more further modules configured to alert a user of the motor vehicle if the oil change interval has been reached.

To avoid unnecessary duplication of effort and repetition of text in the specification, certain features are described in relation to only one or several aspects or embodiments of the invention. However, it is to be understood that, where it is technically possible, features described in relation to any aspect or embodiment of the invention may also be used with any other aspect or embodiment of the invention within the scope of the claims below.

Brief Description of the Drawings

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a block diagram depicting a method for a previously proposed oil life monitor;

Figure 2 is a schematic diagram depicting an oil system for an engine of a motor vehicle;

Figure 3 is a graph depicting the reduction in Total Base Number of oil within motor vehicle engines as a function of running time of the engines;

Figure 4 is a block diagram depicting a method for an oil life monitor according to arrangements of the present disclosure; and

Figure 5 is a block diagram depicting a method for an oil life monitor according to another arrangement of the present disclosure.

Detailed Description

With reference to Figure 2, an engine assembly 1 for a motor vehicle comprises an oil system 2, a crank shaft 14 provided within a crankcase 15, and a plurality of pistons 16 configured to reciprocate within a plurality of cylinders 18. The engine assembly 1 further comprises a valve train 20 comprising a plurality of inlet and outlet valves 22, 24 and a camshaft 26.

The inlet and outlet valves 22, 24 are configured to control the flow of inlet and exhaust gases into and out of the cylinders 18 respectively. The camshaft 26 is configured to control the operation of the inlet and outlet valves 22, 24.

The inlet and outlet valves 22, 24 may be provided within a cylinder head of the engine assembly 1, and the cylinders 18 and crankcase 15 may be provided within, e.g. formed by, a cylinder block of the engine assembly 1.

The cylinders 18, the cylinder head and the pistons 16 together define combustion chambers of the engine assembly 1 within which fuel is mixed with the inlet gases and combusted to produce combustion gases. The expanding combustion gases drive the pistons 16 within the cylinders 18 to turn the crankshaft 14.

The pistons 16 each comprise one or more piston rings 16a configured to improve the sealing between the pistons 16 and the respective cylinders 18 in order to prevent the combustion gases from leaking out of the cylinders 18 into the crankcase 15. However, a portion of the exhaust gases, known as blow-by gases, often leak past the piston rings 16a into the crankcase 15. The engine assembly 1 may comprise a crankcase ventilation system (not shown) configured to remove blow-by gases from the crankcase 15.

The oil system 2 comprises an oil pump 4 configured to draw oil from an oil sump 6 via an oil pick-up 8 to an inlet 4a of the oil pump 4. The oil pump 4 may be driven by the engine. For example, as shown in Figure 2, the oil pump 4 may be driven by the crank shaft 14 via a drive belt 5. The oil pick up 8 may comprise a pick-up filter 8a configured to reduce the amount of particles or debris drawn from the oil sump 6 into the oil system 2.

The oil pump 4 may be configured to pump a flow of oil through the oil system 2. The oil pump 4 may be a fixed oil pump configured such that the oil flow rate and/or outlet oil pressure supplied by the oil pump 4 depends on the running speed of the engine. Alternatively, the oil pump 4 may be a variable displacement oil pump configured to allow the pressure of oil supplied by the oil pump to be controlled independently of engine speed.

The oil system 2 may further comprise an oil filter 10, which may be configured to filter the oil to reduce the quantity of particles present in the oil being pumped through the oil system 2.

The oil system 2 further comprises an oil life monitor 200 configured to determine when an oil change interval has been reached and alert the driver to the need to change to oil. The oil life monitor 200 may be a dedicated controller of the oil system 2. Alternatively, the oil life monitor 200 may be provided as part of another system, such as an engine system or powertrain system. For example, the oil life monitor 200 may be an engine control unit or power train control module. Alternatively, the oil life monitor 200 may be another controller of the motor vehicle, such as a body control unit. The oil life monitor 200 may be configured to receive signals, e.g. from an engine revolution sensor 210 and/or the engine control unit, providing information such as engine rotations and distance travelled, to be used for determining the oil change interval.

The engine assembly 1 may comprise a plurality of journal bearings. The journal bearings may be configured to support portions 28 of the crank shaft 14 and may allow the crank shaft 14 to rotate relative to the crankcase 15 of the engine assembly 1. Each of the journal bearings may comprise a journal bearing oil feed 28a. Oil may flow through the oil feeds 28a into each of the journal bearings and may lubricate the journal bearings to reduce friction between the portions 28 of the crank shaft 14 and the journal bearings.

An oil duct 12 may deliver oil from the oil filter 10 to an oil channel 14a provided in the crank shaft 14. The oil channel 14a may be configured to allow oil to flow through the crank shaft 14 to the journal bearing oil feeds 28a.

As shown in Figure 2, the engine assembly 1 may further comprise a plurality of Piston Cooling Jets (PCJs) 30. Each of the piston cooling jets may be configured to direct a jet of oil onto a respective piston 16 of the engine assembly. Providing the jet of oil from the piston cooling jets 30 may cool and lubricate the pistons 16 and may improve the efficiency of the engine assembly 1. Use of the piston cooling jets 30 may be particularly beneficial when the engine is operating at a high running speed or under a high load.

Oil may be delivered to the journal bearing, e.g. via the journal bearing oil feeds 28a, substantially constantly during operation of the engine assembly. Additionally, when the PCJs 36 are active, e.g. when the engine is operating at a high running speed or under a high load, oil may be constantly supplied to a bottom surface of the pistons 16, e.g. outside of the engine combustion chambers. Oil that is supplied to the journal bearings and piston may return to the oil sump 6 by draining through the crankcase 15.

Within the crankcase 15, the oil may be exposed to the blow-by gases that have leaked from the cylinders 18 past the piston rings 16a. The blow-by gases may comprise acidic compounds, such as NO_X, that may detrimentally affect the operation of the engine assembly 1. As described above, the engine assembly 1 may comprise a crankcase ventilation system configured to remove blow-by gases from the crankcase 15. Additionally, the oil may comprise base compound additives to neutralise the acidic compounds within the blow-by gases in order to protect the components of the engine assembly.

Total Base Number (TBN) is a property of engine oil that reflects the concentration of base additives within the engine oil. TBN is typically expressed as the equivalent number of milligrams of potassium hydroxide per gram of oil sample (mg KOH/g)

New engine oil typically has a TBN value of approximately 7.21 mg KOH/g and it has been found that when the TBN of oil is reduced below a threshold value of 1.5 mg KOH/g, the engine assembly 1 may begin to be detrimentally affected by acidic compounds introduced into the crankcase 15 within the blow-by gases.

With reference to Figure 3, lines L1, L2 and L3 shown on the graph depict the TBN value of engine oil within three different respective engine assemblies over a period of operation of the three different engines. As shown, the line L1 corresponding to a first engine drops below a value of 1.5 at an operating time of approximately 440,000 seconds, whilst the line L2 corresponding to a second engine drops below a value of 1.5 at an operating time of approximately 1,310,000 seconds, and the line L3 corresponding to a third engine does not drop below the threshold of 1.5 mg of KOH/g during the test.

During testing of the plurality of engine assemblies, it was determined that the TBN value of the oil was reduced to the threshold of 1.5 mg of KOH/g over a shorter period of operating time, and after travelling a fewer number of miles, than the respective times and distance over which the concentrations of other additives of the oil (that may not relate to the TBN value) were reduced to their respective desirable thresholds. The concentration of TBN within the oil is therefore a suitable characteristic of the oil to be used to represent oil quality.

The TBN value of the oil reduces as an exponential decay with a decay constant that is a function of the amount of acidic compounds the oil is exposed to, e.g. within the blow-by gas, and the temperature of the oil, which affects the rate of the reaction between the oil additives and the acidic compounds.

It was found that the concentration of acidic compounds varies during normal operation of the engine assembly 1 according to the amount of torque being developed by the engine. More particularly, the concentration of acidic compounds varies according to a ratio of the amount of torque being developed by the engine to the peak torque that may be produced by the engine.

Equation (1) was developed to enable the TBN value of oil to be determined from the torque developed by the engine assembly 1 over a period of operation of the engine assembly.

$$TBN(t) = TBN_0 \cdot e^{-\tau \cdot t} \qquad (1)$$

$$\tau = a \cdot 3 \cdot 10^{-6} \cdot \frac{T_{avg}}{T_{peak}}$$

Where t is engine running time, e.g. in seconds, TBN_0 is the TBN value of new engine oil, T_{avg} is an average, e.g. time average, engine torque calculation, for example, over a drive cycle, e.g. a period of operation of the engine assembly, or as a rolling average since the last oil change; T_{peak} is peak torque for the engine and a may be a constant or may be determined according to equation (2).

$$a = c1 \cdot (EOT - 100)^{c2} + c3 \qquad (2)$$

Where EOT is engine oil temperature in degrees Celsius, e.g. measured in a main oil gallery or oil sump of the engine, and c1, c2 and c3 are constants determined through experimentation or using any other desirable method.
Alternatively, the constant a may be determined according any other desirable equation, which may include engine oil temperature and/or any desirable number of constants determined through experimentation on in any other way.

Determining a current TBN value of the oil by using a function the torque developed by the engine over a drive cycle is beneficial, as engine torque is a parameter that is often determined by Engine Control Units (ECUs) provided on modern vehicles. Hence, by applying equation (1) to determine the TBN value, oil quality can be calculated without additional sensors being provided within the engine assembly or multiple further calculations being performed in order to determine additional parameters for the TBN calculation.

With reference to Figure 4, the oil life monitor 200 according to the present disclosure may be configured to determine when the oil within the engine assembly 1 should be replaced by applying equation (1) within a method 400.

The method comprises a first block 402, in which it is determined whether the engine assembly has travelled a distance greater than or equal to a predetermined distance since a previous oil change. In a second block 404 of the method, it is determined whether the engine assembly has been operating for a period of time greater than or equal to a predetermined period of time since the previous oil change. The first and second blocks may be substantially the same as the first and second blocks 102, 104 of the method 100 depicted in Figure 1 and the predetermined distance and the predetermined period of time may be the same as those considered when using the method 100.

In a third block 406, the quality of the oil is estimated and it is determined whether the oil quality is less than or equal to a predetermined quality threshold. In the method 400 the estimation of oil quality is performed using equation (1) to calculation a TBN value of the oil. The predetermined quality threshold of the oil is a minimum desirable TBN value, typically considered to be 1.5 mg of KOH/g.

A fourth block 408 of the method 400 may be similar to the fourth block 108 of the first method 100 and may comprise an “OR” gate configured to determine whether it has been determined in the first, second or third blocks 402, 404, 406 that the oil should be changed.

If it is determined in the fourth block 408 that the oil should be changed, e.g. if it has been determined in one or more of the first, second and third blocks 402,404,406 that an oil change may be required, the method proceeds to a fifth block 410, in which the driver is alerted to the need to replace the engine oil soon.

When the method 400 initially proceeds to the fifth block 410, approximately 5% or less of the oil life may remain and the driver may initially be informed that the oil should be changed soon, at block 410a. The method 400 may remain operating in the fifth block 410 until a further predetermined period of time, e.g. engine operating time, has elapsed (determined in block 410b) or a further predetermined distance has been travelled (determined in block 410c). After the further predetermined period of time has elapsed, or the further predetermined distance has been travelled, the driver may be alerted that an oil change is now required in block 410d.

By using equation (1) to calculate a TBN value of the oil to be used as a characteristic for defining oil quality within the method 400, oil quality is determined more accurately over a greater range of drive cycles compared to oil quality calculations performed using engine revolutions. The oil quality calculation may therefore be less conservative for most drive cycles performed in the vehicle, increasing the number of miles and/or the length of time before an oil change is deemed necessary. In some cases, determining oil quality using equation (1) as part of the method 400 may allow the vehicle to reach the predetermined distance or predetermined period of time before the oil quality, e.g. TBN, is reduced to undesirable levels.

With reference to Figure 5, in some arrangements, the oil life monitor 200 may apply a method 500 in which oil quality calculations are made using equation (1) above, e.g. to calculate a change in TBN of the oil, and further oil quality calculations are made using engine revolution information, in order to determine an oil change interval. The further oil quality calculations may enable the oil life monitor to determine, e.g. estimate, an oil quality that is indicative of characteristics of the oil other than TBN, such as soot content.

The method 500 may be similar to the method 400 and may comprise first, second, third, fourth and fifth blocks 502, 504, 506, 508, 510 that are substantially the same as first, second, third, fourth and fifth blocks 402, 404, 406, 408, 410 of the method 400 described above. The method 500 may further comprise a sixth block 512 in which the quality of oil is estimated using engine revolution information 507, e.g. in the same way as in the third block 106 of the method 100.

In the sixth block 512 it may be determined whether oil quality is estimated to be below a predetermined threshold value. In the fourth block 508, the “OR” gate may additionally receive an input signal from the sixth block 512 and may determine whether it has been determined in any of the first, second, third or sixth blocks 502, 504, 506, 512 that the oil interval has been reached.

The method 500 may account for situations in which TBN is not the first oil quality characteristic to be reduced below a desirable level during operation of the motor vehicle.

The method 500 may further comprise a seventh block 514, in which a quantity of oil within the oil system is determined and is compared to a predetermined threshold quantity. The oil quantity may be measured by referring to an oil level sensor, e.g. provided in the oil sump 6 of the engine assembly 1. Alternatively the oil quantity may be estimated, e.g. using the engine revolution information 507. If it is determined that the oil quantity has been reduced below the predetermined threshold quantity, the driver may be alerted in an eighth block 516 to check the oil level.

The determination of oil quantity may be performed separately to the oil quality and oil change interval calculations performed by the oil life monitor 200 and the determination may also be performed as parts of the method 400. Furthermore, the addition of oil to the oil system 2 between oil changes may not affect the oil interval calculation performed by the oil life monitor 200.

It will be appreciated by those skilled in the art that although the invention has been described by way of example, with reference to one or more exemplary examples, it is not limited to the disclosed examples and that alternative examples could be constructed without departing from the scope of the invention as defined by the appended claims.

Claims

1. A method for determining an oil change interval comprising:

determining an oil quality of oil within an oil system of a motor vehicle, wherein the oil quality is determined as a function of a ratio of engine torque to peak engine torque;

determining whether an oil change interval has been reached based on the oil quality.

2. The method of claim 1, wherein the oil quality is determined as a function of oil temperature and engine torque.

3. The method of any of the preceding claims, wherein the function of engine torque is an exponential decay function, wherein an exponential decay constant is based on the engine torque.

4. The method of any of the preceding claims, wherein the oil quality corresponds to a concentration of an additive within the oil.

5. The method of any of the preceding claims, wherein the method further comprises:

determining at least one of a distance travelled by the motor vehicle and an operating time of the motor vehicle since a previous oil change; and

determining whether the oil change interval has been reached based on the distance travelled and/or operating time.

6. The method of any of the preceding claims, wherein the method further comprises:

determining a further oil quality, wherein the further oil quality is determined according to a function of the number of revolutions performed by an engine of the motor vehicle; and

determining whether an oil change interval has been reached based on the further oil quality.

7. The method of any of the preceding claims, wherein the method further comprises:

alerting a user when the oil change interval is reached.

8. The method of any of the preceding claims, wherein the method further comprises:

determining or predicting a quantity of oil within the oil system of the motor vehicle; and

alerting a user if the quantity of oil may be below a threshold quantity.

9. The method of claim 8, wherein the quantity of oil within the oil system is determined according to a number of revolutions performed by an engine of the motor vehicle.

10. An oil system for a motor vehicle, the system comprising and controller having one or more modules configured to:

determine an oil quality of oil within an oil system of a motor vehicle, wherein the oil quality is determined as a function of a ratio of engine torque to peak engine torque;

determine whether an oil change interval has been reached based on the determined oil quality.

11. The oil system of claim 10, wherein the controller comprises one or more further modules configured to:

determine at least one of a distance travelled by the motor vehicle and an operating time of the motor vehicle since a previous oil change; and

determine whether the oil change interval has been reached based on the distance travelled and/or operating time.

12. The oil system of claim 11, wherein the controller comprises one or more further modules configured to:

determine whether the oil change interval has been reached based on oil quality, distance travelled and/or operating time; and

alert a user of the motor vehicle if the oil change interval has been reached.