



(11)

**EP 2 851 540 B1**

(12)

## EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention  
of the grant of the patent:  
**01.07.2020 Bulletin 2020/27**

(51) Int Cl.:  
**F02D 29/04** <sup>(2006.01)</sup> **F02D 41/02** <sup>(2006.01)</sup>  
**E02F 9/22** <sup>(2006.01)</sup>

(21) Application number: **14185537.9**

(22) Date of filing: **19.09.2014**

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(54) **Anti-lug and anti-stall control unit**

Steuerungseinheit zum Schutz vor Drückung und Abwürgen

Unité de commande anti-calage et anti baisse de régime

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(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB  
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO  
PL PT RO RS SE SI SK SM TR**

(30) Priority: **20.09.2013 GB 201316755**

(43) Date of publication of application:  
**25.03.2015 Bulletin 2015/13**

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## Description

### Technical field

[0001] The present invention relates to a control unit which controls the output of a pump, in particular a hydraulic pump used in heavy machinery such as industrial or agricultural machinery. The control unit configured to vary the output of the pump to prevent stall or lug of the engine.

### Background

[0002] Engines on heavy machinery are known to be subjected to variable demands. Such demands may vary according to the environment in which the machinery is placed and the task being performed.

[0003] The engine on such machinery typically powers the main components of the machine including the powertrain and a hydraulic pump which controls attachments such as excavating arms and the like. When a large load is placed on the hydraulic pump the demand on the engine is increased. In certain situations the increased demand placed on the engine by the hydraulic system may cause the engine speed to decrease which may result in engine lug or stall, which is undesirable.

[0004] Conventional methods of controlling a hydraulic system of construction machinery are disclosed in US 2009/0269213 A1, WO 2009/145706 A1 and EP 1 571 339 A1.

[0005] According to an aspect of the invention there is provided a control unit according to independent claim 1.

[0006] The control unit may be configured to receive one or more further operating parameters, and compare the one or more further operating parameters to a predetermined range indicative of desired engine performance, and if the one or more operating parameters are outside of the predetermined range selectively varying the power supplied to the hydraulic pump until the operating parameter of the engine is within the predetermined range.

[0007] The operating parameter may be one or more engine speed and engine torque.

[0008] The predetermined range may be indicative of an engine stall or engine lug.

[0009] The value of the first and second predetermined range may be different.

[0010] The second predetermined range may be greater than the first predetermined range.

[0011] The controller may be configured to determine the amount the power supplied to the hydraulic pump is to be varied dependent on the difference of the operating parameter and the first predetermined range.

[0012] The control unit may be configured to incrementally decrease the power supplied to the hydraulic pump.

[0013] The control unit may be configured to decrease the power supplied to the hydraulic pump by a maximum amount.

[0014] The maximum amount may be 15%.

[0015] The controller may be configured to determine the amount the power supplied to the hydraulic pump is to be varied using look-up tables.

[0016] The controller may be configured to determine the amount the power supplied to the hydraulic pump is to be varied as a linear interpolation between a maximum and minimum engine speed.

[0017] A vehicle may comprise the control unit.

[0018] The control unit monitors one or more factors indicative of the current engine performance, such as torque, engine speed etc., and varies the load applied to the pump according to current engine performance. In particular if the load required by the pump would result in engine lug or stall the control unit will alter the load provided to the pump to prevent lug or stall. In a first embodiment the control unit is able to react to a change in demand, and in the event that the change in demand on the engine results in the engine performance decreasing, the load applied to the pump will allow the engine to recover.

[0019] According to a further aspect of the present invention there is provided a method of controlling the operation of an engine which powers a hydraulic pump and a powertrain of a vehicle, according to independent claim 11.

[0020] The method may further comprise the steps of:

receiving, at the control unit, one or more further operating parameters;  
comparing the one or more further operating parameters to a predetermined range indicative of desired engine performance;  
determining if the one or more operating parameters are outside of the predetermined range as a result of the comparison; and if  
the one or more operating parameters is outside of the predetermined range selectively varying the power supplied to the hydraulic pump until the operating parameter of the engine is within the predetermined range.

[0021] The engine may be a compression ignition engine, the engine may be a diesel engine or the like.

[0022] The vehicle may be a materials handling machine such as a back hoe loader, a telehandler, an agricultural tractor, an excavator, or the like.

[0023] The pump may provide hydraulic fluid to actuators, such as single acting hydraulic rams, double acting hydraulic rams, hydraulic motors and the like. The actuators may move material handling arms, telescopic arms, buckets, shovels and the like in order to handle material which is required to be moved.

[0024] According to a further aspect of the present invention there is provided a control unit which controls the operation of an engine which powers a hydraulic pump; the control unit configured to selectively vary the power supplied to the hydraulic pump, the control unit further

configured to;  
determine an amount of excess engine performance available at a current engine speed,

determine a desired demand of engine performance from the hydraulic pump, compare the amount of excess engine performance with the desired demand, and if the amount of excess engine performance is less than the desired demand, provide the hydraulic pump with an amount of engine performance that is less than the desired demand.

**[0025]** The amount of engine performance provided to the hydraulic pump may be provided when the engine is operating at substantially said current engine speed e.g. when the engine is operating at the current engine speed, or when the engine is operating at more than 20 rpm below said current engine speed, or when the engine is operating at more than 50 rpm below said current engine speed.

**[0026]** According to a further aspect of the present invention there is provided a method of controlling the operation of an engine which powers a hydraulic pump, with a control unit configured to selectively vary the power supplied to the hydraulic pump, the method comprising the steps of:

determining an amount of excess energy performance available at a current speed,  
determining a desired demand of engine performance from the hydraulic pump,  
comparing the amount of excess energy performance with desired demand, and

when the amount of excess energy performances is less than the desired demand, providing the hydraulic pump with an amount of engine performance that is less than the desired demand.

### Brief description of the drawings

**[0027]** Embodiments of the invention are now described, by way of example only, with reference to the accompanying drawing in which:

Figure 1 is a schematic of the apparatus according to an aspect of the invention;

Figure 2 is a flow chart of the process of preventing engine stall according to an aspect of the invention;

Figure 3 is a flow chart of the process of preventing engine lug according to an aspect of the invention; and

Figure 4 is a flow chart of the process of ensuring that engine speed does not decrease to a according to an aspect of the invention.

### Detailed description of an embodiment

**[0028]** According to an aspect of the invention there is provided a control unit which selectively controls the power supplied to various components of a vehicle in order to minimise the possibility of engine stall or lug.

**[0029]** Figure 1 is a schematic representation of the apparatus according to an aspect of the invention. There is shown the vehicle 10 which comprises an engine 12, control unit 14, a powertrain 16, a hydraulic pump 18 and CAN bus 20. As will be appreciated the vehicle 10 comprises a number of further components which would typically be found in heavy industrial or agricultural machinery, though these for the purpose of clarity are not shown.

**[0030]** The engine 12 may be a compression ignition engine for example diesel engine or the like, the engine 12 configured to provide power to both the powertrain 16 of the vehicle 10, and the hydraulic pump 18 of the vehicle 10. The control unit 14 is configured to vary the amount of power supplied by the engine 12 to the powertrain 16 and hydraulic pump 18 according to the operation of the vehicle 10. The distribution of the power supplied by the engine 12 to either the powertrain 16 or pump 18 occurs via known means, in particular those which are found on excavating vehicles and the like.

**[0031]** The hydraulic pump 18 in a preferred embodiment is a mechanical pump. The pump is electrically controlled by pump control circuitry with the amount of current supplied by the pump control circuitry affecting the power output of the pump. The control circuitry therefore does not directly power the pump rather by changing the current output regulates the power output of the pump. Such a method of pump control is found on commercially available products.

**[0032]** In use, the vehicle 10 may be driven, with power supplied by the engine 12 to the powertrain 16. Optionally, the hydraulic pump 18 may also be engaged depending on the particular usage of the vehicle. Accordingly, in use the control unit 14 will allocate power from the engine 12 to the powertrain 16 and pump 18 with the amount of power allocated to each element dependent on the particular load demand. The load demand of the hydraulic pump 18 will vary according to the type of act performed and the particulars of the act (for example the extension and weight of material to be carried by a hydraulic arm).

**[0033]** Therefore, the hydraulic pump 18 will have a variable load demand and the combined demand of the powertrain 16 and hydraulic pump 18 may exceed the power output of the engine 12. In such situations, the engine may slow down resulting in stall or engine lug. Accordingly, in the present invention the control unit 14 is configured to actively change the amount of power supplied to the hydraulic pump 18 in order to prevent engine lug or stall.

**[0034]** In use, the control unit 14 receives an input from the CAN 20. The CAN signal from the CAN bus 20 providing an indication of the current performance of the

engine 12. In an example, the CAN signal is indicative of the torque generated by the engine 12 thus allowing the control unit 14 to make a determination of the output of the engine 12, and to determine whether the engine 12 is capable of sustaining the output or whether it will eventually lug or stall.

**[0035]** In the event that the control unit 14 determines that the CAN bus 20 that the load on the engine exceeds the maximum load of the engine the amount of power supplied to the hydraulic pump 18 by the engine 12 is reduced, preferably by reducing the current supplied to the control unit of the hydraulic pump, therefore reducing the power supplied to the hydraulic pump 18 and thus allowing the engine time to recover and thus preventing engine lug or stall. This process is described below in detail with reference to Figures 2, 3 and 4.

**[0036]** Figure 2 is a flowchart of the process of controlling the hydraulic pump 18 so as to prevent engine stall. Therefore the process in Figure 2 functions by measuring engine speed as an operating parameter of the engine.

**[0037]** At step S102 the engine speed is monitored by the control unit. The engine speed is preferable measured in RPM and provided to the control unit 14 by the CAN bus 20.

**[0038]** At step S104 the engine speed, as determined at step S102, is compared to an anti-stall value. The anti-stall value is indicative of the minimum engine speed at which the engine 12 can function for a prolonged period of time. In a preferred embodiment, the anti-stall value is 1,200 RPM with a tolerance of  $\pm 5\%$ , though this value will be dependent on the type and size of engine.

**[0039]** At step S106 the control unit determines whether the engine speed is greater than the anti-stall value. In the event that the engine speed is greater than the anti-stall value no further action need be taken and the process returns to step S102 to continue to monitor the engine speed. In the event that the engine speed is the same as, or lower than, the stall value the process proceeds to step S108.

**[0040]** At step S108 the system enters into a stall recovery mode in which the power supplied to the hydraulic pump 18 by the engine 12 is decreased in order to reduce the overall load on the engine 12 so that the engine may recover. Therefore, at step S108 the control unit reduces the current supplied to the control unit of the hydraulic pump, thereby reducing the power of the hydraulic pump, in order to allow the engine to recover.

**[0041]** Preferably, the current supplied to the control unit 14 is reduced in a step wise manner in which the current is incrementally decreased in order to prevent a total removal of power to the hydraulic pump 18. Preferably, in order to ensure that the hydraulic pump is able to safely function there is a maximum amount by which the current is reduced, preferably by 15%.

**[0042]** At step S110 the engine speed is determined using the CAN bus 20 and compared to a stall recovery speed. Preferably, the stall recovery speed is greater than the anti-stall speed in order to enable the engine to

recover from the stall. In a preferred embodiment, the stall recovery speed is 1,400 RPM  $\pm 5\%$  as compared to the anti-stall speed of 1,200 RPM. In other embodiments the stall recovery speed is dependent on the type and size of engine.

**[0043]** If the stall recovery speed is greater than the measured engine speed the system determines that the stall has been averted and the process returns to step S102 in which normal monitoring of the system may resume. In the event that the measured engine speed is less than the stall recovery speed the process returns to step S108 in which the current supplied to the control unit 14 of the hydraulic pump 18 is further reduced. This process continues until such time that the engine has recovered as indicated by the engine speed being greater than the stall recovery speed.

**[0044]** Figure 3 is a flowchart of the process of preventing engine lug according to an aspect of the invention. The process in Figure 3 functions by measuring engine torque as an operating parameter of the engine.

**[0045]** Preferably the control unit allows the anti-stall function as described above with reference to Figure 2, to override any function regarding the anti-lug function as described below with reference to Figure 3.

**[0046]** Figure 3 is a flow chart of the process describing the anti-lug functionality of the control unit 14.

**[0047]** At step S202 the engine output torque is measured using an input signal from the CAN bus. The engine torque is measured using known means.

**[0048]** At step S204 a filtered engine torque percentage value is determined. The torque of an engine fluctuates over very short periods of time and such fluctuations must be accounted for in order to prevent the process from entering an anti-lug mode when a minor fluctuation occurs. In a preferred embodiment the filtered engine torque presented value is calculated using a rolling average of the torque values over a pre-defined period of time. Preferably, the pre-defined period of time is 100 milliseconds. In further embodiments different periods of time may be used. In further embodiments, other methods for accounting for fluctuations of the torque value may also be used, for example the identification of statistical outliers and removal of said outliers.

**[0049]** At step S206 the filtered torque percentage value is compared to an anti-lug value. The anti-lug value is dependent on the type of engine used and would be different for each engine. In a preferred embodiment, the anti-lug value is 10%.

**[0050]** At step S208 it is determined whether at step S206 the filtered torque value is greater than or equal to the anti-lug value or whether it is less than the anti-lug value. In the event that the determination shows that the filtered torque value is less than the anti-lug value, it is indicative of the engine functioning within its normal parameters and no remedial action need be taken. Accordingly, the process returns to step S202 so that the control unit may continue to monitor the engine torque output. If the filtered torque value is less than or equal to the anti-

lug value it is an indication that the engine is lugging or would shortly begin to lug if no remedial action were taken, and the process proceeds to step S210 in order to enter a lug recovery mode.

**[0051]** At step S210 the current supplied to the control unit 12 is reduced to the hydraulic pump. This is as described above with the equivalent step S108 in Figure 1. In a preferred embodiment, the current is reduced by 250mA though this may be changed according to the type of control used, hydraulic pump used, envisaged applications of the machinery etc.

**[0052]** At step S212 a new filtered engine torque percentage value is determined. This filtered engine torque percentage value is determined as described above with reference to step S204. The filtered engine torque percentage value is subsequently compared to a lug recovery torque percentage which is indicative of the engine recovering from a period of engine lug. Accordingly, the lug recovery torque percentage is greater than the anti-lug torque percentage. In a preferred embodiment the lug recovery torque percentage is 15%. If it is determined that the filtered engine torque percentage is below the lug recovery torque percentage, it is indicative of the engine having not recovered from the period of engine lug and accordingly the process returns to step S210 in which the current percentage to the pump is further reduced. The process continues until such time that the filtered engine torque percentage value is greater than the lug recovery value thereby indicating that the engine has recovered from the period of lug.

**[0053]** Preferably, the control unit 14 is further configured to disable the anti-lug functionality as described above with reference to Figure 3 in the event that the machine is determined to be travelling. In a preferred embodiment if the machine is determined to be travelling for more than a period of 5 seconds the anti-lug functionality is disabled.

**[0054]** Figure 4 is a flowchart of the process of preventing engine lug and stall by using an engine speed. When the engine is heavily loaded by the hydraulic pump 18 the engine 12 may not have sufficient power to maintain the required engine speed. In the event that it is determined that the engine speed falls below a predetermined target speed remedial action is taken in which the loading of the hydraulic pump 18 is reduced thus allowing the engine to recover to the optimal speed. Figure 5 is a plot of engine speed versus hydraulic pump control current from which a reduction in hydraulic pump control current may be determined according to the speed of the engine as per the process of Figure 4.

**[0055]** In Figure 4 there is shown the process of using the engine speed in order to affect any remedial action to prevent engine stall or lug.

**[0056]** At step S302 the engine speed is measured. The engine speed is measured using any number of known methods. Preferably determining the RPM of the engine. The RPM of the engine may be supplied by the CAN bus to the control unit.

**[0057]** At step S304 the engine speed as measured at step S302 is compared to a number of predetermined values. An engine has a no load engine speed in which a minimum engine speed is obtained when there is no hydraulic load to be supplied by the engine. The no load engine speed is dependent on the type of engine used. In the embodiment shown in Figure 5 the no load engine speed is 2,050 RPM. As it is known for engines to undergo minor variations from the standard speed, in order to account for such variations a hydraulic pump backoff start engine speed is defined. The pump backoff start engine speed defines the speed at which any remedial action must commence. As with the no load engine speed the value of the hydraulic pump backoff start engine speed is dependent on the type of engine and in the example shown in Figure 5 is defined as 20 RPM less than the no load engine speed. There is also defined the maximum pump backoff end engine speed which is defined as 70 RPM less than the no load engine speed in the preferred embodiment as shown in Figure 5. Therefore at step S304 the engine speed is compared to the pump backoff start speed and the pump backoff end speed.

**[0058]** At step S306 the response of the system is determined as a result of the comparison step as S304. In the event that the engine speed is determined to be greater than the pump backoff start engine speed, it is an indication that the engine has sufficient power to complete the task and accordingly no action is taken. The process returns to step S302. In the event that the engine speed is determined to be less than the pump backoff end engine speed it is an indication that the engine may not have sufficient power to maintain the required engine speed. As it is important to balance the requirements of both the engine and the hydraulic pump, which may be in the middle of a heavy lifting operation or the like, a maximum pump current reduction percentage is defined. This ensures that the hydraulic pump remains sufficiently powered to ensure safe operation of the pump. In a preferred embodiment the maximum pump current reduction is 15% of the standard pump current. As shown in Figure 5 the standard pump control current is 600 mA and the maximum current reduction is 510 mA i.e. 85% of 600 mA.

**[0059]** In the event that the measured engine speed is between the pump backoff start engine speed and the pump backoff end engine speed (i.e. between 1,980 RPM and 2,030 RPM as shown in the embodiment in Figure 5) then the hydraulic pump control current is reduced, the reduction of the current being dependent on the engine speed. In the embodiment shown in Figure 5 a linear interpolation between the pump back off start engine speed and the pump back off end engine speed is used in order to determine the level of reduction. In a further embodiment, other forms of mathematical interpolations may be used, and/or lookup tables. It is the realisation that the hydraulic pump need only be reduced by a specific amount which enables the pump to function as well as ensuring that the engine speed is maintained, which

ensures continued and safe operation of the vehicle.

**[0060]** In a further embodiment there is provided a process of limiting the energy absorbed by the hydraulic pump such that engine lug or engine stall does not occur.

**[0061]** By way of background, an engine is capable of producing different amounts of power at a particular engine speed. Thus, for example, a vehicle such as a materials handling machine such as a back hoe loader may have an engine which is running at 2000 rpm. If the back hoe loader is stationary and the back hoe or loader are not being operated, then the engine is required to do very little work. In effect the engine is "idling". Clearly the fuel consumption of such an idling engine will be relatively low, demonstrating relatively little work is being done.

**[0062]** However, the same vehicle, when the back hoe is in use, for example digging ground, may have the engine running at the same speed (2000 rpm) but under these circumstances the engine is required to carry out more work, i.e. the engine is required to drive the hydraulic pump which in turn operates the hydraulic rams of the back hoe. Under these circumstances, whilst the engine is still running at 2000 rpm, nevertheless the fuel consumption will be significantly higher, demonstrating that a significant amount of work is being done.

**[0063]** As will be appreciated, when the engine is "idling" at 2000 rpm there will be an amount of excess engine performance available at that 2000 rpm engine speed. The amount of excess energy performance available is the difference between the maximum engine performance available at 2000 rpm and the engine performance with the engine at idle and running at 2000 rpm. Engine performance may be measured as engine power, or alternatively the engine performance may be measured as engine torque. With an engine running at "idle" at 2000 rpm, it is possible to determine the amount of excess energy performance available at current (2000 rpm) speed. For example, look up tables would be able to provide this information. In other words the amount of excess engine performance available at a current (2000 rpm) speed is the extra amount of engine performance the engine could provide if the controller "up fuels" the engine so that it is running at its maximum performance at the current (2000 rpm) engine speed.

**[0064]** When an operator desires to operate a hydraulic service, such as a back hoe, an operator input device, such as a joystick or the like, can be used to input a desired movement of the back hoe. In one example a relatively small movement of the joystick is indicative of desire for a relatively small movement of the back hoe and/or indicative of a desire for a relatively slow movement of the back hoe. As will be appreciated, a relatively large movement of the joystick is indicative of desire for a relatively large movement of the back hoe and/or a relatively quick movement of the back hoe. Since the back hoe is operated via rams powered by a hydraulic pump, the desired movement of the back hoe defines a desired demand of engine performance from the hydraulic pump. Thus, the operator wishes to move the back

hoe quickly, then this will require a higher amount of engine performance than if the back hoe is desired to be moved slowly.

**[0065]** Thus, knowing an amount of excess engine performance available at a current engine speed, and knowing a desired demand of engine performance from the hydraulic pump, a comparison can be made. If the amount of excess energy performance is less than the desired demand of engine performance from the hydraulic pump, then this is an indication that the engine will lug or stall if the desired demand of engine performance from the hydraulic pump is applied to the engine. Under these circumstances an aspect of the invention is not to apply the desired demand of engine performance to the hydraulic pump, rather it is to provide the hydraulic pump with an amount of engine performance that is less than the desired demand. In this manner, the engine will not lug or stall.

**[0066]** In particular, such an aspect of the invention ensures that no lugging or stall of the engine occurs since the engine performance used by the hydraulic pump is less than the desired energy performance that the operator wishes to apply to the pump.

**[0067]** Thus, one aspect of the present invention is to determine an amount of excess energy performance and compare that with a desired demand of engine performance. If the desired demand of engine performance is greater than the amount of excess engine performance, then the desired demand of engine performance is not applied to the pump, rather an amount of engine performance less than the desired demand is applied to the hydraulic pump. This prevents engine lug or stall. Significantly, such a system does not need to wait for a reduction in engine speed and then react to that reduced engine speed to allow recovery, rather the system prevents application of an excess load, i.e. it only applies a load that the engine, at the particular engine speed, is capable of dealing with. This aspect of the present invention is "proactive" rather than "reactive".

**[0068]** The control unit may also increase the engine performance of the engine at the particular engine speed. In response to this increasing engine performance at the particular engine speed, the control unit may then incrementally increase the amount of engine performance provided to the hydraulic pump. Thus, consider the situation where an engine is "idling" at 2000 rpm. The operator operates a joystick or the like that requires a demand of engine performance that, if applied quickly, will cause the engine to lug. The control unit, by making a comparison between the amount of excess engine performance available when the engine is idling at 2000 rpm, and the desired demand of engine performance required by the operator (i.e. the desired demand of engine performance from the hydraulic pump) will recognise that the demand, if applied quickly, will cause the engine to lug. The control unit therefore does not apply the whole demand to the pump quickly, rather it applies part of that demand to the pump such that the engine will not lug. The control unit

also will increase the performance of the engine at 2000 rpm, e.g. will increase the fuel supply to the engine. As the fuel supply to the engine is increased then the performance of the engine at 2000 rpm increases and this in turn allows the controller to apply a greater amount of engine performance to the pump in response to the increasing engine performance at 2000 rpm. Ultimately the controller will have increased the engine performance at 2000 rpm to a maximum engine performance, and this maximum engine performance will be applied to the pump.

**[0069]** In such a manner, the engine can continually run at 2000 rpm, in other words there is no need for the engine speed to drop below 2000 rpm since at no point is the engine excessively loaded by the hydraulic pump. This aspect of the present invention therefore only applies engine performance to the pump which the engine is capable of delivering without lugging or stalling. In this example the engine speed is 2000 rpm. Clearly, this aspect of the invention is applicable to any engine rpm to prevent engine lug. Clearly, at relatively low engine rpm this aspect of the invention also prevents engine stall. In the present example, and as mentioned above, the engine can continually run at 2000 rpm, in other words there is no need for the engine speed to drop below 2000 rpm since at no point is the engine excessively loaded by the hydraulic pump. Clearly, the present "proactive" approach to preventing excessive loading of the engine by a hydraulic pump still allows for relatively small drops in engine speed, for example the drop in engine speed 20 rpm, or a drop in engine speed of 50 rpm are both consistent with this aspect of the present invention, since in particular it is not necessary to monitor any relatively small drop in rpm since the system is being controlled by virtue of making a comparison between the amount of excess engine performance with the desired demand.

**[0070]** The above embodiments and concepts may also be used to determine how much hydraulic load can be applied and how quickly whilst ensuring that the engine's operating parameters (e.g. speed, torque etc.) remain within the desired range.

**[0071]** The above processes described with reference to Figures 2, 3 and 4 and other processes described above may be used in conjunction or separately from each other.

**[0072]** The invention may be implemented using an onboard processor in which the instructions to implement the above processes are encoded thereon. Alternatively, the processes may be introduced as a software module which resides on an existing onboard computer which is configured to control other operations which are typically found in such machinery.

**[0073]** The invention is described with reference to the hydraulic pump control current being varied in order to ensure optimal engine performance. The above concepts may also be used in systems which drive the hydraulic pump directly.

**[0074]** Therefore, the present invention ensures that

the engine of the vehicle is able to function within an optimal range. In the event that the load required by the hydraulic pump would cause the engine to function in a non-optimal manner, for example stalling, lugging or reducing in engine speed, the load applied to the hydraulic pump is decreased in the manner so as to allow the engine to recover. Furthermore, the invention ensures that the hydraulic pump is sufficiently powered so as to maintain safe operation of the hydraulic pump. Such a configuration is particularly important in heavy industrial machinery and agricultural machinery where the powering of a hydraulic pump and powertrain by the same engine requires careful management of the engine in order to ensure optimal and safe performance of the vehicle.

## Claims

1. A control unit which controls the operation of an engine which powers a hydraulic pump; the control unit configured to selectively vary the power supplied to the hydraulic pump, the control unit further configured to; determine an amount of excess engine performance available at a current engine speed, wherein the excess engine performance is the difference between a maximum engine performance available at a current engine speed and the engine performance at idle at said current engine speed, determine a desired demand of engine performance from the hydraulic pump, compare the amount of excess engine performance with the desired demand, and if the amount of excess engine performance is less than the desired demand, provide the hydraulic pump with an amount of engine performance that is less than the desired demand and increase the engine performance at the engine speed.
2. A control unit as defined in claim 1 wherein the pump is provided with an amount of engine performance that is less than the amount of excess engine performance.
3. A control unit as defined in claim 1 wherein the hydraulic pump is provided with an amount of engine performance that is less than the desired demand by a maximum amount.
4. A control unit as defined in claim 3 wherein the maximum amount is 15%.
5. A control unit as defined in any preceding claim wherein the controller is configured to determine the amount of engine performance provided to the hydraulic pump using look up tables.
6. A control unit as defined in any preceding claim in which the control unit incrementally increases the

amount of engine performance provided to the hydraulic pump in response to the increase in engine performance at the engine speed.

7. A control unit as defined in any preceding claim wherein the engine performance is engine power. 5
8. A control unit as defined in any one of claims 1 to 6 wherein the engine performance is engine torque. 10
9. A control unit as defined in any preceding claim in which the control unit controls the operation of an engine which powers the hydraulic pump and a power train of a vehicle. 15
10. A vehicle unit including the control unit of any preceding claim.
11. A method of controlling the operation of an engine which powers a hydraulic pump, with a control unit configured to selectively vary the power supplied to the hydraulic pump, the method comprising the steps of: 20

determining an amount of excess energy performance available at a current speed, wherein the excess engine performance is the difference between a maximum engine performance available at a current engine speed and the engine performance at idle at said current engine speed, 25  
determining a desired demand of engine performance from the hydraulic pump, comparing the amount of excess energy performance with desired demand, and 30  
when the amount of excess energy performance is less than the desired demand, providing the hydraulic pump with an amount of engine performance that is less than the desired demand and increasing the engine performance at the engine speed. 35

12. A method as defined in claim 11 wherein the step of providing the hydraulic pump with an amount of engine performance that is less than the desired demand consists of providing the hydraulic pump with an amount of engine performance that is less than the amount of excess engine performance. 40

#### Patentansprüche

1. Steuereinheit, welche den Betrieb eines Motors steuert, der eine Hydraulikpumpe antreibt, wobei die Steuereinheit dazu beschaffen ist, die der Hydraulikpumpe zugeführte Leistung selektiv zu variieren, wobei die Steuereinheit ferner dazu beschaffen ist: 55

einen Betrag an überschüssiger Motorleistung zu bestimmen, die bei einer momentanen Motorgeschwindigkeit verfügbar ist, wobei die überschüssige Motorleistung der Unterschied zwischen einer maximalen Motorleistung, die bei einer momentanen Motorgeschwindigkeit verfügbar ist, und der Motorleistung im Leerlauf bei der momentanen Motorgeschwindigkeit ist, einen Wunschbedarf an Motorleistung von der Hydraulikpumpe zu bestimmen, den Betrag an überschüssiger Motorleistung mit dem Wunschbedarf zu vergleichen, und, wenn der Betrag an überschüssiger Motorleistung kleiner ist als der Wunschbedarf, die Hydraulikpumpe mit einem Betrag an Motorleistung zu versorgen, der kleiner ist, als der Wunschbedarf, und die Motorleistung bei der Motorgeschwindigkeit zu erhöhen.

2. Steuereinheit nach Anspruch 1, wobei die Pumpe mit einem Betrag an Motorleistung versorgt wird, der kleiner ist als der Betrag an überschüssiger Motorleistung.
3. Steuereinheit nach Anspruch 1, wobei die Hydraulikpumpe mit einem Betrag an Motorleistung versorgt wird, der um einen Maximalbetrag kleiner ist als der Wunschbedarf. 25
4. Steuereinheit nach Anspruch 3, wobei der Maximalbetrag 15 % beträgt. 30
5. Steuereinheit nach einem der vorherigen Ansprüche, wobei die Steuerung dazu beschaffen ist, den Betrag an der Hydraulikpumpe zugeführter Motorleistung unter Verwendung von Nachschlagetabellen zu bestimmen. 35
6. Steuereinheit nach einem der vorherigen Ansprüche, wobei die Steuereinheit den Betrag an der der Hydraulikpumpe zugeführter Motorleistung in Erwiderung auf die Zunahme der Maschinenleistung bei der Motorgeschwindigkeit stufenweise erhöht. 40
7. Steuereinheit nach einem der vorherigen Ansprüche, wobei die Motorleistung Nutzleistung ist. 45
8. Steuereinheit nach einem der Ansprüche 1 bis 6, wobei die Nutzleistung Motordrehmoment ist. 50
9. Steuereinheit nach einem der vorherigen Ansprüche, wobei die Steuereinheit den Betrieb eines Motors steuert, der die Hydraulikpumpe und einen Antriebsstrang eines Fahrzeugs antreibt
10. Fahrzeugeinheit, enthaltend die Steuereinheit nach einem der vorherigen Ansprüche.

11. Verfahren zum Steuern des Betriebs eines Motors, der eine Hydraulikpumpe antreibt, mit einer Steuereinheit, die dazu beschaffen ist, die der Hydraulikpumpe zugeführte Leistung selektiv zu variieren, wobei das Verfahren die folgenden Schritte umfasst:

Bestimmen eines Betrags an überschüssiger Motorleistung, die bei einer momentanen Motorgeschwindigkeit verfügbar ist, wobei die überschüssige Motorleistung der Unterschied zwischen einer maximalen Motorleistung, die bei einer momentanen Motorgeschwindigkeit verfügbar ist, und der Motorleistung im Leerlauf bei der momentanen Motorgeschwindigkeit ist, Bestimmen eines Wunschbedarfs an Motorleistung von der Hydraulikpumpe, Vergleichen des Betrags an überschüssiger Motorleistung mit dem Wunschbedarf, und Versorgen der Hydraulikpumpe, wenn der Betrag an überschüssiger Motorleistung kleiner ist als der Wunschbedarf, mit einem Betrag an Motorleistung, der kleiner ist, als der Wunschbedarf, und Erhöhen der Motorleistung bei der Motorgeschwindigkeit.

12. Verfahren nach Anspruch 11, wobei der Schritt des Versorgens der Hydraulikpumpe mit einem Betrag an Motorleistung, der kleiner ist, als der Wunschbedarf, aus dem Versorgen der Hydraulikpumpe mit einem Betrag an Motorleistung, der kleiner ist, als der Betrag an überschüssiger Motorleistung, besteht.

## Revendications

1. Unité de commande qui commande le fonctionnement d'un moteur qui alimente une pompe hydraulique, l'unité de commande configurée pour varier sélectivement l'énergie fournie à la pompe hydraulique étant en plus configurée pour :

déterminer un excédent de rendement du moteur disponible à un régime courant du moteur, l'excédent de rendement du moteur étant la différence entre un rendement maximal du moteur disponible à un régime courant du moteur et le rendement du moteur au régime de ralenti du moteur, déterminer une demande désirée de rendement du moteur par la pompe hydraulique, comparer l'excédent de rendement du moteur avec la demande désirée, et si l'excédent de rendement du moteur est inférieur à la demande désirée, fournir à la pompe hydraulique un niveau de rendement du moteur qui est inférieur à la demande désirée et augmenter le rende-

ment du moteur en fonction du régime du moteur.

2. Unité de commande suivant la revendication 1, dans laquelle est fourni à la pompe hydraulique un rendement du moteur, dont le niveau est inférieur à l'excédent de rendement du moteur.
3. Unité de commande suivant la revendication 1, dans laquelle est fourni à la pompe hydraulique un rendement du moteur, dont le niveau est inférieur, d'une quantité maximale, à la demande désirée.
4. Unité de commande suivant la revendication 3, dans laquelle la quantité maximale s'élève à 15%.
5. Unité de commande suivant une des revendications précédentes, dont le régulateur est configuré pour déterminer le niveau de rendement du moteur fourni à la pompe hydraulique en utilisant des tables de consultation.
6. Unité de commande suivant une des revendications précédentes, l'unité de commande augmentant progressivement le niveau de rendement du moteur fourni à la pompe hydraulique en réponse à l'augmentation du rendement du moteur en fonction du régime du moteur.
7. Unité de commande suivant une des revendications précédentes, dans laquelle le rendement du moteur est la puissance du moteur.
8. Unité de commande suivant une des revendications précédentes 1 à 6, dans laquelle le rendement du moteur est le couple du moteur.
9. Unité de commande suivant une des revendications précédentes, l'unité de commande régulant le fonctionnement d'un moteur qui alimente la pompe hydraulique et une chaîne cinématique d'un véhicule.
10. Unité embarquée sur un véhicule incluant l'unité de commande suivant une des revendications précédentes.
11. Procédé de régulation du fonctionnement d'un moteur qui alimente une pompe hydraulique au moyen d'une unité de commande configurée pour varier sélectivement l'énergie fournie à la pompe hydraulique, le procédé comprenant les étapes consistant à :

déterminer un excédent de rendement énergétique disponible à un régime courant, l'excédent de rendement du moteur étant la différence entre un rendement maximal du moteur disponible à un régime courant du moteur et le rendement du moteur au régime de ralenti du moteur,

déterminer une demande désirée de rendement du moteur par la pompe hydraulique, comparer l'excédent de rendement avec la demande désirée, et lorsque le niveau des excédents de rendements énergétiques est inférieur à la demande désirée, fournir à la pompe hydraulique un niveau de rendement du moteur qui est inférieur à la demande désirée et augmenter le rendement du moteur en fonction du régime du moteur.

12. Procédé suivant la revendication 11, dans lequel l'étape consistant à fournir à la pompe hydraulique un niveau de rendement du moteur qui est inférieur à la demande souhaitée consiste à fournir à la pompe hydraulique un niveau de rendement de moteur qui est inférieur au niveau de rendement excédentaire de moteur.

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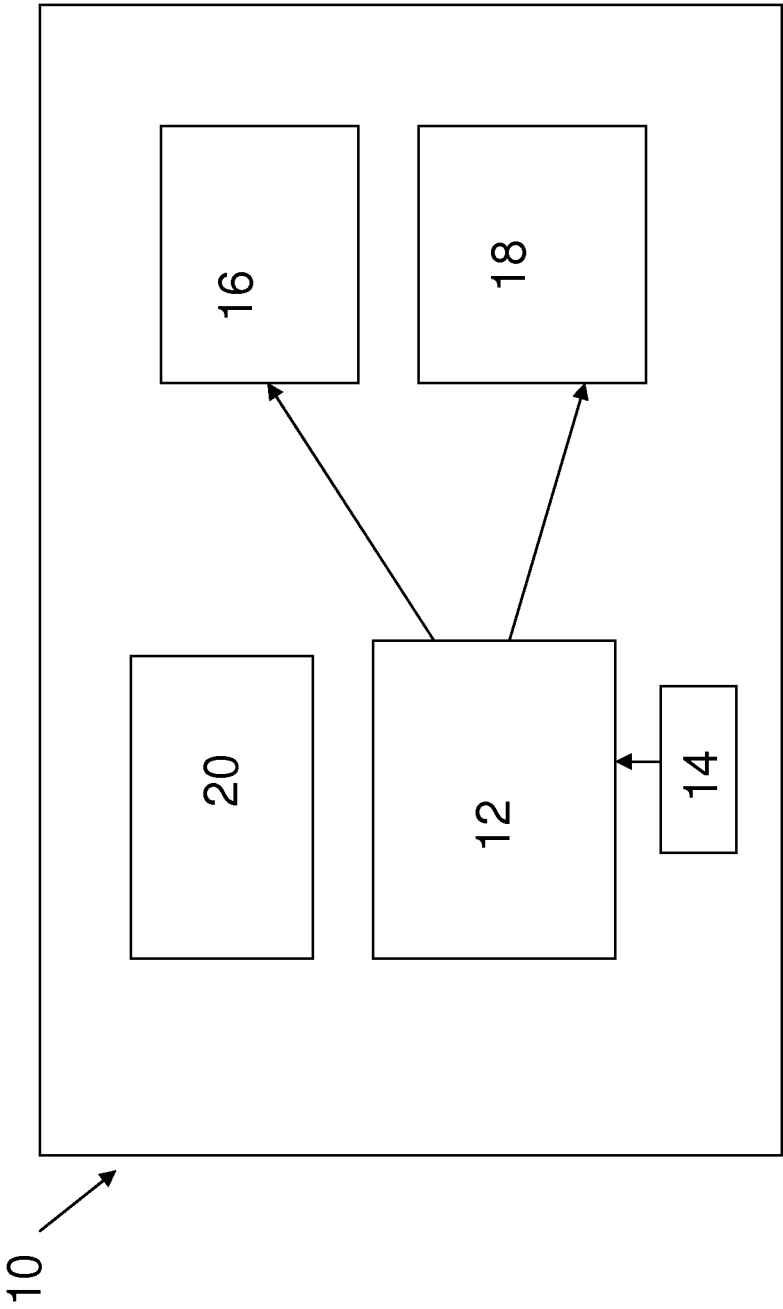


Figure 1

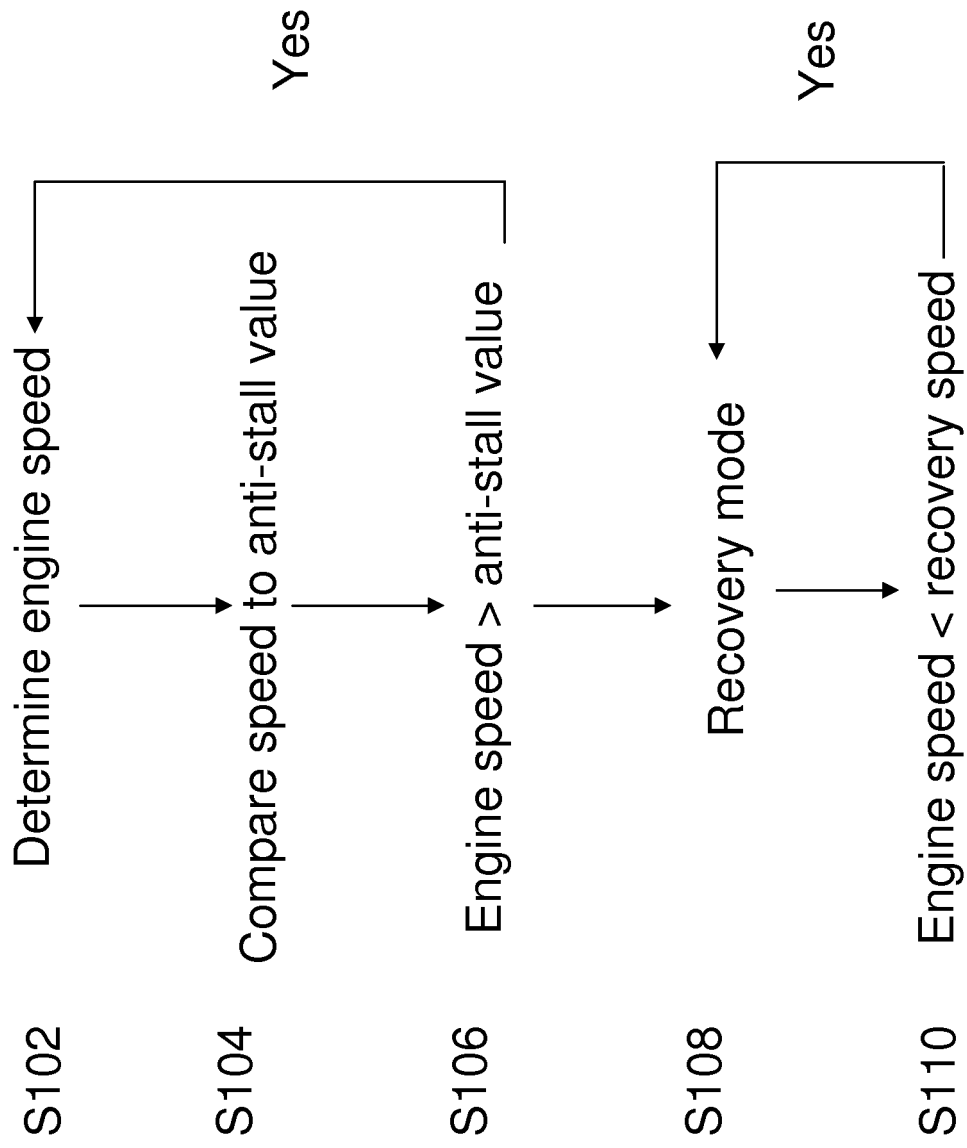


Figure 2

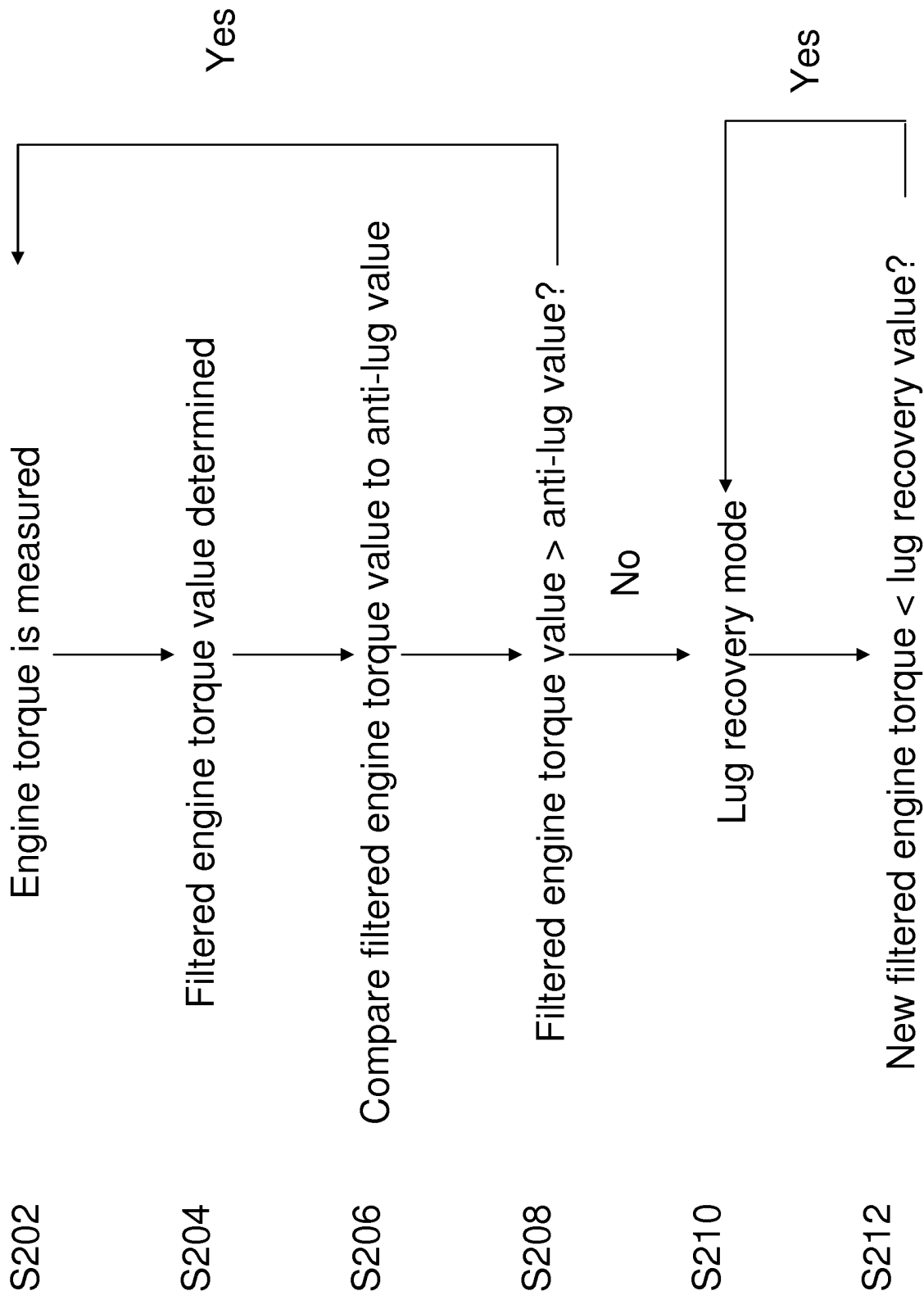


Figure 3

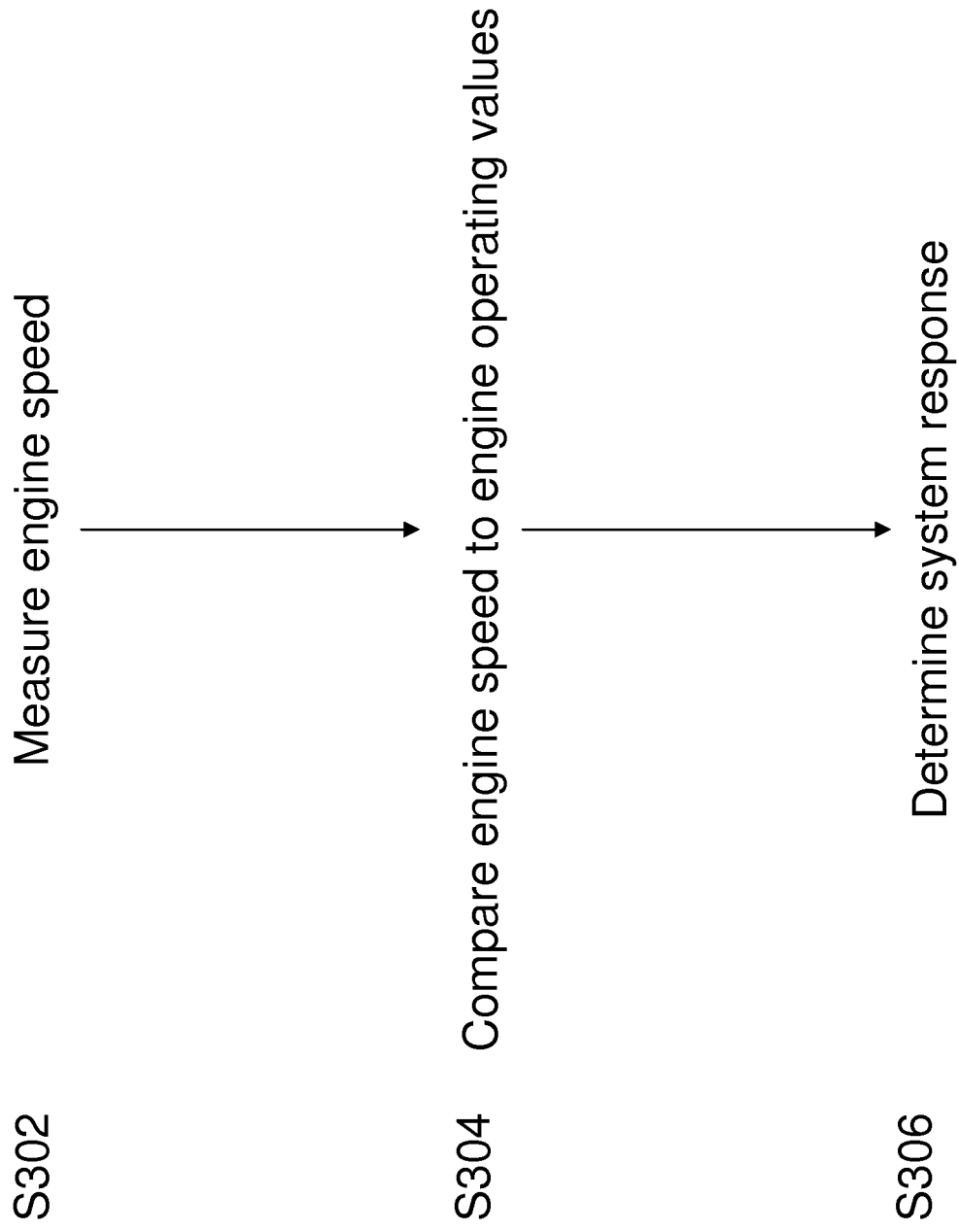


Figure 4

## "Speed Sensing" for Hydraulic Pump

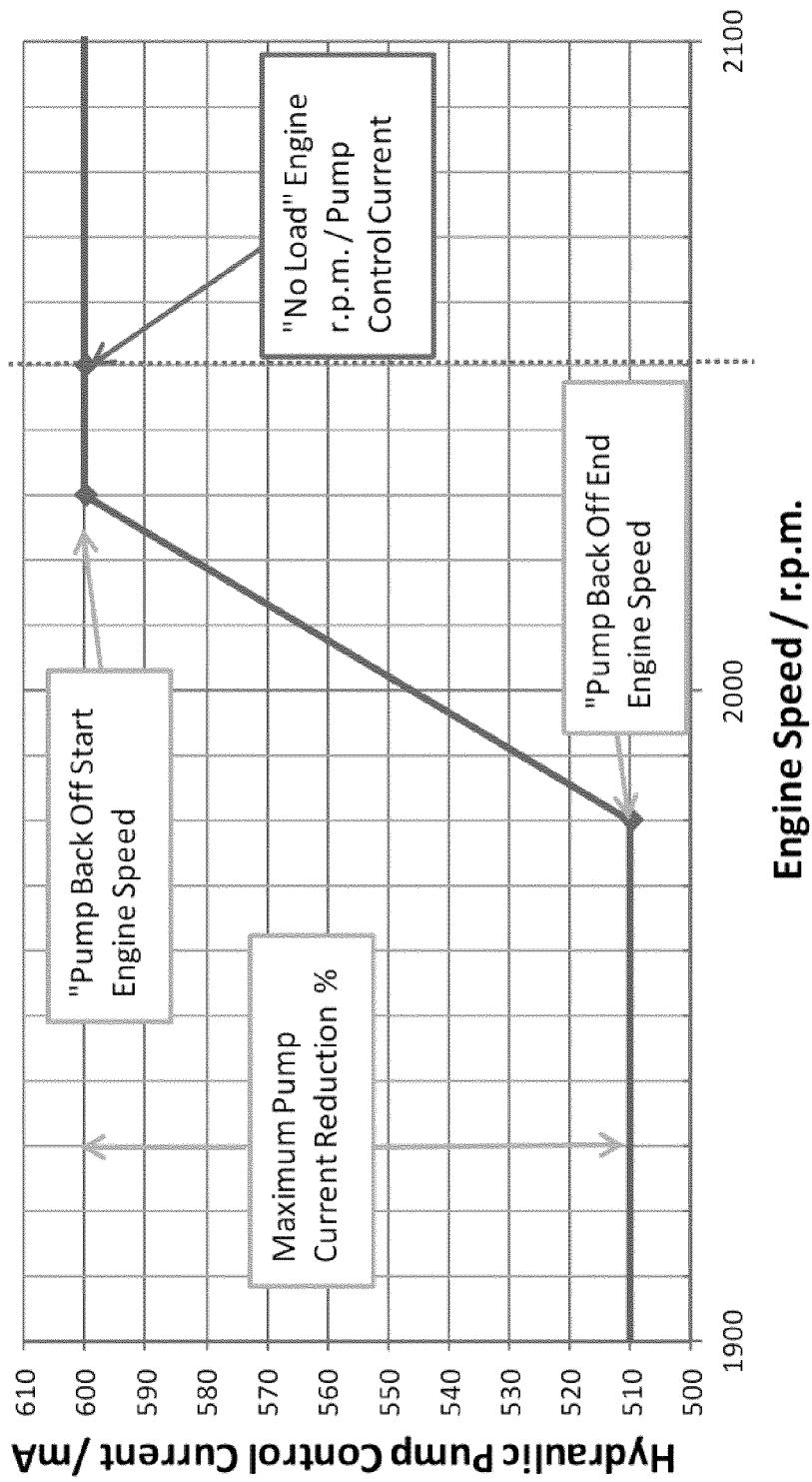


Figure 5

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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