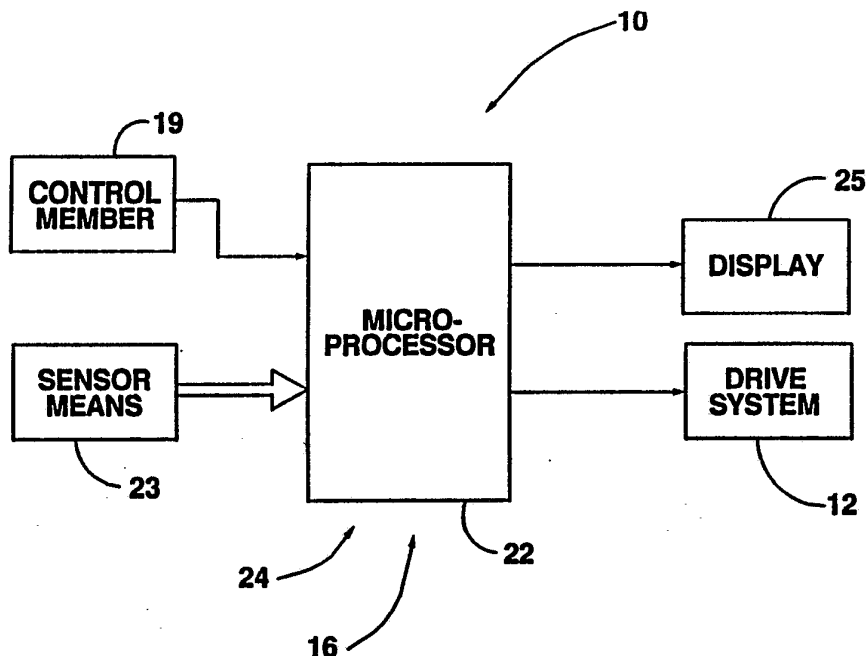




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<p>(21) International Application Number: PCT/US91/09742 (22) International Filing Date: 23 December 1991 (23.12.91)</p> <p>(71) Applicant (for all designated States except US): CATERPIL-LAR INC. [US/US]; 100 Northeast Adams Street, Peoria, IL 61629-6490 (US).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only) : JUDY, Steven, William [US/US]; 1119 W. Sycamore, Chillicothe, IL 61523 (US). SMITH, Vernon, Richard [US/US]; 6826 Patricia Lane, Peoria, IL 61614 (US). STAHL, Alan, Lee [US/US]; 617 W. Detweiller Drive, Peoria, IL 61615-2120 (US).</p> <p>(74) Agents: VANDER LEEST, Kirk, A. et al.; Caterpillar Inc., 100 Northeast Adams Street, Peoria, IL 61629-6490 (US).</p>		<p>(81) Designated States: AU, BR, CA, CH, DE, DK, ES, FI, GB, JP, KR, NL, NO, RO, SE, SU, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, MC, NL, SE).</p> <p><b>Published</b> <i>With international search report.</i></p>

(54) Title: VEHICLE DIAGNOSTIC CONTROL SYSTEM



(57) Abstract

In accordance with one aspect of the present invention, an apparatus (10) is provided for a vehicle equipped with a drive system (12) and a controller (16) for regulating the operating speed of the drive system. The apparatus (10) includes at least one sensor (23) for sensing a vehicle parameter and producing a parameter signal in response to the sensed parameter. A diagnostic device (24) is provided for receiving the parameter signal, processing the parameter signal to detect the presence of an undesirable operating condition; determining the severity of the undesirable operating condition in accordance with a preselected strategy and responsively producing a severity level signal. The controller (16) receives the severity level signal and limits the maximum speed of the vehicle in response to the severity level signal, whereby the maximum allowable vehicle speed decreases as the severity level signal increases.

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DescriptionVEHICLE DIAGNOSTIC CONTROL SYSTEM5 Technical Field

This invention relates to a monitoring and control system for a vehicle and, more specifically, to a system which limits the available driving power in response to the severity of a sensed fault.

10

Background Art

In a variety of engine-powered vehicles, monitoring devices are employed to detect the presence of various undesirable operating conditions, such as  
15 overheating of the engine, low oil pressure, low fuel, electrical system faults and the like. Known systems provide indicators, such as warning lights, for alerting an operator of these sensed conditions.

The importance of the various monitored  
20 conditions usually varies as to criticality. For example, the air filter for the engine or the filter for the hydraulic fluid may gradually clog during operation of the vehicle. The vehicle operator should be warned of such clogging, but generally there is no  
25 need to remedy the situation until the end of the day when the vehicle returns for normal servicing and maintenance. A low fuel condition requires more immediate attention from the operator. A loss of engine oil pressure or a loss of hydraulic fluid  
30 represent conditions which require immediate operator attention to prevent damaging the vehicle.

United States Patent No. 4,184,146, which issued to Fratzke et al. on January 15, 1980 and is assigned to the assignee herein, recognizes and  
35 partially addresses the above problems. Fratzke

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et al. provides a system for warning a vehicle operator of an undesirable operating condition of one or more of a plurality of monitored operating parameters of an engine-powered vehicle. Three  
5 degrees of warning are given, depending upon the criticality of the monitored parameter. Individually energizable low-intensity warning indicators are provided for each of the monitored parameters, and a multiplexing circuit is provided for staggered pulsing  
10 of the indicators. The existence of any critical fault will cause an intermittent operation of a more intense warning device, while the existence of a highly critical fault results in an additional intermittent warning of a still greater degree of  
15 intensity.

If an operator ignores the warnings and continues to operate the vehicle, it is possible for the vehicle to be severely damaged. Hence, it is desirable to limit the operating power which is  
20 available when faults are detected. It is further desirable to limit the available power as a function of the severity of the detected faults.

The present invention is directed towards overcoming one or more of the problems as set forth  
25 above.

#### Disclosure of the Invention

In accordance with one aspect of the present invention, an apparatus is provided for a vehicle  
30 equipped with a drive system and a controller for regulating the operating speed of the drive system. The apparatus includes at least one sensor for sensing a vehicle parameter and producing a parameter signal in response to the sensed parameter. A diagnostic  
35 device is provided for receiving the parameter signal,

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processing the parameter signal to detect the presence of an undesirable operating condition, determining the severity of the undesirable operating condition in accordance with a preselected strategy, and  
5 responsively producing a severity level signal. The controller receives the severity level signal and limits the maximum speed of the vehicle in response to the severity level signal, whereby the maximum allowable vehicle speed decreases as the severity  
10 level signal increases.

In accordance with another aspect of the present invention, the apparatus includes a plurality of sensors for sensing vehicle parameters and responsively producing respective parameter signals.  
15 A diagnostic device is provided for receiving the parameter signals, processing the parameter signals to detect the presence of undesirable operating conditions, determining a severity level for each detected undesirable operating conditions in  
20 accordance with a preselected strategy, determining the highest severity level for which an undesirable operating condition presently exists and producing a severity level signal in response to the highest detected severity level. The controller receives the  
25 severity level signal and limits the maximum speed of the vehicle in response to the severity level signal, whereby the maximum allowable vehicle speed decreases as the severity level signal increases.

In accordance with still another aspect of the present invention, an apparatus is provided for a vehicle equipped with a hydrostatic drive system. The hydrostatic drive system includes first and second hydrostatic transmissions. Each hydrostatic transmission includes a fluid pump driven by an engine  
30 and being responsive to a respective control signal to  
35

provide pressurized fluid in proportion thereto and a fluid motor connected to the pump and driven by the pressurized fluid. The vehicle drive system further includes an electronic control for producing the control signals to control the speed of fluid motors. The apparatus includes a plurality of sensors for sensing vehicle parameters and responsively producing respective parameter signals. A diagnostic device is provided for receiving the parameter signals; processing the parameter signals to detect the presence of undesirable operating conditions; classifying the detected undesirable operating conditions into one of a preselected number of hierarchical severity levels; determining the highest severity level for which an undesirable operating condition presently exists; and producing a severity level signal corresponding to the highest detected severity level. The electronic controller receives the severity level signal and limits the magnitude of the control signals in response to the severity level signal, whereby the maximum allowable value of the control signal decreases as the severity level signal increases.

#### 25 Brief Description of the Drawings

Fig. 1 is a schematic illustration of an embodiment of the present invention;

Fig. 2 is an electronic control for incorporating the present invention in a hydrostatic drive system;

Figs. 3A-B is a detailed schematic of the hydrostatic drive system used in connection with the electronic control of Fig. 2;

Fig. 4 is a flow chart illustrating a computer program for practicing the present invention

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in with the system of Fig. 2 or with an engine controller; and,

Fig. 5 is a flowchart illustrating a computer program for practicing the present invention  
5 in a transmission controller.

#### Best Mode for Carrying Out the Invention

The present invention concerns a method and apparatus for detecting faults in a vehicle and for  
10 limiting the speed of vehicle in response to the severity of the detected faults. While the apparatus is described in connection with a vehicle, it should be understood that the present invention could readily be applied in other engine powered applications, such  
15 as an engine-powered electrical generator unit, where it is desirable to limit the speed of the engine in response to detected faults. Several embodiments of the invention in a vehicle application are disclosed herein; however, the system was originally developed  
20 for use on a model 943B track type loader which is manufactured by the assignee herein. This embodiment will be explained in greater detail below in connection with Figs. 2 and 3A-B.

Referring now to Fig. 1, the invention will  
25 be generally described. A monitoring and control apparatus 10 is provided for a vehicle (not shown), such as a track type loader, equipped with a drive system 12 and a controller means 16 for regulating the operating speed of the drive system 12. The drive  
30 system 12 is shown generally in Fig. 1; however, it is explained in greater detail below in connection with Figs. 3A-B.

The controller means 16 is connected to a manually operable control member 19 for receiving a  
35 desired speed signal. In the context of a track type

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loader the control member is in the form of a speed/direction lever (see Fig. 2). Similarly, in an on-highway truck, the control member 19 is embodied in an accelerator pedal (not shown.) The controller means 16 processes the input signals, as explained below, and produces a control signal which is delivered to the drive system 12 for controlling the speed of the vehicle.

Preferably, the controller means 16 is implemented employing a microprocessor 22 with appropriate input and output signal conditioning circuits and memory devices (not shown) as would be apparent to one skilled in the art. A number of commercially available microprocessors are adequate to perform the function of the controller means 16; however, preferably the microprocessor 22 is a model MC6809 as manufactured by Motorola Semiconductor, Inc. of Phoenix, Arizona. The microprocessor 22 operates under software control to perform the functions of the controller means 16 as would be apparent to one skilled in the art.

The apparatus 10 includes at least one sensor means, indicated generally by reference numeral 23, which is provided for sensing a vehicle parameter and producing a parameter signal in response to the sensed parameter. Preferably, a plurality of a plurality of sensors are provided for sensing respective vehicle parameters hydraulic fluid pressure and engine speed, and responsively producing respective parameter signals. The sensor means 23 can be embodied in a variety of commercially available sensors such as pressure transducers, coolant sensors, magnetic pick-up sensors, etc. The parameter signals can include, but are not limited to, pulse width modulated (PWM), frequency, and analog signals. It

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should be understood that the various parameter signals could also be obtained from other vehicle control and monitoring systems (not shown) such as payload monitors, engine control systems, etc. which are commonly present on engine-powered vehicles.

The parameter signals are delivered to a diagnostic means 24 through appropriate conditioning and interface circuits (not shown), as would be apparent to one skilled in the art. As shown in Fig. 1, the controller means 16 and the diagnostic means 24 are both embodied in a single microprocessor 22. However, it should be apparent that these means 16,24 could be embodied in separate microprocessors connected via a communications link. The diagnostic means 24 processing the parameter signals to detect the presence of an undesirable operating conditions (i.e., operating faults.) The exact nature of the parameter diagnostics depends on the particular application for which the apparatus 10 is used; therefore, specific diagnostics will not be explained in greater detail herein. For example in some applications it might be desirable to monitor engine temperature to determine if the engine is in an overheat condition.

The diagnostic means 24 also receives input signals from the various control means 19 and processes these signals to diagnose undesirable operating conditions in the vehicles electrical system (i.e., system faults.) Examples of diagnostics include tests for electrical faults such as harness faults, open circuit, shorts circuits to ground and battery, and failed sensors. Such diagnostics are common in the art and will not be explained in great detail. Additionally, in the context of the hydrostatic drive system of Figs. 2 and 3A-B,

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diagnostics are performed to detect if various electrical control valves in the drive system are functioning properly.

The diagnostic means 24 is further  
5 programmed to determine the severity level of each detected undesirable operating condition in accordance with a preselected strategy. More specifically, the diagnostic means 24 classifies each detected  
10 undesirable operating condition into one of a preselected number of hierarchical severity levels. In the preferred embodiment, the apparatus 10 classifies each undesirable operating condition into one of four severity levels depending on the criticality of the undesirable operating condition.  
15 It would be within the scope of the present invention to use fewer or greater than four warning levels if desired. In the preferred embodiment classes A, B, C, and D are provided wherein class A corresponds to the most critically type of fault and class D corresponds  
20 to the least critical type of fault. It should be understood that a given undesirable operating condition may be classified at any one of the severity levels in dependance on the criticality of the detected fault. For example, if engine  
25 temperature, the undesirable operating condition may be classified as A, B, C, or D in dependence on the sensed engine temperature.

It may be possible for more than one undesirable operating condition to be present at a  
30 given instance of time. Therefore, the diagnostic means 24 determines the highest severity level for which an undesirable operating condition presently exists and responsively produces a severity level signal which corresponds to the highest detected  
35 severity level.

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The severity level signal is delivered to the controller means 16 which limits the magnitude of the maximum speed of the vehicle in response to the severity level signal. This is accomplished by  
5 modifying the control signal in response to the severity level signal. More specifically, the controller means 16 receives the severity signal, and produces a shutdown factor in response to the severity level signal. Preferably, the shutdown factor is a  
10 value between 0% and 100%, wherein a different shutdown factor is selected for each of the value of the severity signal. In the preferred embodiment, the value of the shutdown factor is set to 0.0 at severity level A, 0.3 at severity level B, 0.5 at severity  
15 level C and 1.0 at severity level D. The controller means 16 multiplies the control signal with the shutdown factor, thereby limiting the value of the control signal to a preselected percentage of its maximum in dependance on the highest detected severity  
20 level. In the case of a hydrostatic drive, the control signal is used to control the speed of fluid powered drive motors and hence vehicle speed, as is explained below.

Similarly, the control signal could be  
25 applied to an engine for controlling the speed thereof. For example, the control signal could correspond to a desired throttle opening of fuel injection rate, as would be apparent to one skilled in the art. Hence, the maximum engine speed can be  
30 limited to a preselected percentage of its maximum in response to the most fault having the highest severity level.

Alternatively, the controller means 16 could be programmed to modify the desired speed signal in  
35 response to the severity level. For example, the

desired speed signal could be multiplied by the shutdown factor, thereby limiting the desired speed signal to a percentage of the requested value in response to the highest detected severity level.

5           In still another embodiment, the apparatus  
10 can be used in connection with a vehicle which includes a multispeed transmission (not shown) and a transmission controller (not shown) for controlling operation of the transmission in response to sensed  
15 vehicle parameters. Both transmissions and transmission controllers are well known in the art; hence, neither is explained in detail herein. In such an embodiment, the transmission controller can be programmed to limit the maximum allowable gear ratio  
20 in response to the severity of a detected fault. More specifically, the transmission controller can be programmed to receive the severity level signal and limit the maximum allowable gear ratio to a different gear ratio in each of the severity levels. In this  
25 manner, the maximum allowable ground speed can be controlled as a function of the highest detected severity level. It is conceivable that it might be desirable to only provide control in this manner when faults are detected in the transmission or transmission controller.

A display means 25 is provided for indicating the undesirable operating conditions corresponding sensed parameters. The display means 25 may take numerous forms such a plurality of display  
30 gages or a single gage which sequentially displays faulty operating conditions, as would be apparent to one skilled in the art.

Referring now to Fig. 2, a more detailed electrical schematic for practicing the present  
35 invention in connection with a hydrostatic drive

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system (see Figs. 3A-B) will be described. A first position sensor 26a is provided for sensing the position of a left steering pedal 28a and responsively producing a left steering signal which is delivered to the microprocessor 22 via an electrical conductor 30. Similarly, a second pedal sensor 26b is provided for sensing the position of a right steering pedal 28b and responsively producing a right steering signal which is delivered to the microprocessor 22 via an electrical conductor 31. Preferably, the first and second sensors 26a,b are in the form of rotary potentiometers which produce output signals responsive to the degree of activation of a respective steering pedal 28a,b. Such sensors are well known in the art and will not be explained in detail herein. A suitable sensor is disclosed in U. S. Patent No. 4,915,075, which issued to Brown and is assigned to the assignee herein.

A manually operable control lever 32 is movable between first and second limits L1,L2 for indicating a desired speed and direction for the fluidly driven motors 212a,b. The first limit L1 indicates full-speed forward, the second position L2 indicates full-speed reverse, and a position intermediate the first and second limits indicates neutral N. The control lever 32 will hereinafter be referred to as the speed/direction (S/D) lever. The S/D lever 32 is provided with a scale (not shown) for indicating when the lever is at zero percent (i.e., neutral), two percent, twenty percent, forty percent, sixty percent, eighty percent and one hundred percent of maximum motor speed in both the forward and reverse directions. Preferably, the S/D lever 32 is infinitely variable between the first and second positions L1,L2; however, in some instances it might

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be desirable to provide a S/D lever having preselected detent positions. For example, the S/D lever 32 could have detents at each of the above-mentioned percentage points.

5                   A third sensor 34 is provided for sensing the position of the S/D lever 32 and responsively producing a desired motor speed/direction signal. The desired speed/direction signal is communicated to the microprocessor 22 via an electrical conductor 36. It  
10 should be apparent that the function of the speed/direction lever 32 could be performed by other devices without departing from the scope of the invention. For example, two levers could be provided for respectively indicating a desired speed and a  
15 desired direction.

The microprocessor 22 is equipped with a memory device 70 which is accessed by the microprocessor 22 in a manner well known in the art. Preferably the memory device 70 includes a random  
20 access memory (RAM) 72, a read only memory (ROM) 74 and an electronically erasable programmable read only memory (EEPROM) 76. The EEPROM 76 is adapted to store data which relates the desired motor speed/direction signal to the first and second control signals in a  
25 preselected manner.

The microprocessor 22 is programmed to receive the desired speed signal, responsively retrieve at least a portion of the data from the memory device 70, and produce the first and second  
30 control signals in response to the retrieved data and the desired speed signal, as explained below.

The first and second signals are delivered to first and second solenoid actuated control valves 80a,b in the hydrostatic drive 200 for controlling the  
35 speed and direction of the first and second motors

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212a,b, respectively. The first and second valves 80a,b are three position proportional valves, each having a forward (F), reverse (R) and neutral (N) position. The control valves 80 are adapted to  
5 receive a charge pressure from a charge pump 215 (see Figs. 3A-B) and deliver a control pressure responsive to the magnitude of the first and second signals, as explained below.

Each of the control valves 80a,b includes a  
10 forward solenoid 82a,b and a reverse solenoid 84a,b for controlling the direction and displacement of a respective valve. Hence, the first and second signals each consist of forward and reverse signals which are delivered to respective forward and reverse solenoids  
15 82, 84. The first (left) forward control signal is communicated from the microprocessor 22 to the first (left) forward solenoid 82a via a conductor 86. The first (left) reverse control signal is communicated from the microprocessor 22 to the first (left) reverse  
20 solenoid 84a via a conductor 87. The second (right) forward control signal is communicated from the microprocessor 22 to the second (right) forward solenoid 82b via a conductor 88. The second (right) reverse control signal is communicated from the  
25 microprocessor 22 to the second (right) reverse solenoid 84b via a conductor 89.

The microprocessor 22 is programmed to controllably deliver one of the forward or reverse control signals to each of the valves 80a,b to effect  
30 vehicle operation in accordance with the steering and S/D signals. The magnitude of the control signal in turn controls the degree of displacement of the control valve 80a,b and hence the speed of a respective motor 212a,b. If neither solenoid 82,84 of  
35 a valve 80 is actuated, the valve 80 is biased to the

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neutral position (N), thereby stopping the flow of pressurized hydraulic fluid to the motor 212.

For purposes of producing the control signals, the EEPROM 76 contains first and second data tables which having data stored therein for relating the desired S/D signal to the first and second control signals in a preselected manner. In the preferred embodiment, the first and second data tables are further divided into respective forward and reverse data tables. Each of the four data tables has an equal number of discrete data elements for relating the desired motor speed signal to a respective one of the first forward, first reverse, second forward and second reverse control signals respectively. More specifically, each data table contains seven discrete data points (i.e., control signal values) which correspond respectively to zero percent, two percent, twenty percent, forty percent, sixty percent, eighty percent and one hundred percent of the respective maximum speed. The first and second signals have electrical currents which vary between a minimum corresponding to the zero percent data point and a maximum corresponding to the 100 percent data point. The remaining data points correspond to the magnitude of the current at a respective percentage of the maximum speed. Control signal currents for speeds which are between the discrete data points are calculated using linear interpolation, as would be understood by one skilled in the art.

If the desired S/D signal indicates forward operation, the microprocessor 22 retrieves at least a portion of the discrete data points from the first and second forward data tables and uses linear interpolation to determine the exact value for the first and second control signals. Conversely, if the

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S/D signal indicates reverse motor operation, the microprocessor 22 retrieves at least a portion of the data points from the reverse data tables to calculate the first and second signals. The control signals are additionally modified in accordance with the steering signals from the left and right steering pedals 28a,b, as would be apparent to one skilled in the art.

A electrohydraulic synchronizing (sync) valve 94 is adapted to receive a sync signal from the microprocessor 22 via a conductor 96. Operation of the sync valve 94 will be explained below in connection with Figs. 3A-B.

Referring now to Figs. 3A-B, a detailed hydraulic schematic of a hydrostatic drive system 200 which can be used with the present invention will be discussed. The hydrostatic drive system 200 includes a pump system 205 which is adapted to provide pressurized fluid to first and second drive motor systems 210a,b through a closed loop hydraulic system. The first and second drive motor systems 210a,b include first and second drive motors 212a,b which are adapted to receive the pressurized fluid and drive respective crawler tracks 214a,b, thereby propelling the vehicle. The pump and motor systems 205, 210a,b are commercially available from Linde Hydraulic of Canfield, Ohio. These systems are available in a variety of drive capacities and the particular systems utilized are selected in accordance with desired vehicle performance characteristics. In the preferred embodiment, the drive system 200 is used on a model 943B track type loader which is manufactured by the assignee herein. On this particular vehicle, the preferred pump and drive systems 205,210 are models BPV-50D and BMV-140, respectively.

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A charge pump 215 is connected to an output shaft 220 of the engine 50 for rotation therewith. The charge pump 215 is adapted to provide pressurized fluid to the pump and drive systems 205, 210a,b as would be apparent to one skilled in the art. Inasmuch as charge pumps are well known in the art, no further description will be provided.

The pump system 205 includes first and second pump units 225a,b for controllably providing pressurized fluid to the first and second drive motor systems 210a,b, respectively. The pump units 225a,b are identical, hence only the first pump unit 225a will be described herein. The pump unit 225a includes a pump controller 228a which is adapted to receive a pump control pressure from the control valve 80a and responsively adjust the direction and displacement of a fluid pump 230a. The fluid pump 230a is coupled to an output shaft 220 of the engine 50 for rotation therewith. The pump 230a is a reversible variable displacement pump having a swash plate 235a for controlling the direction and displacement of the pump 230a as is common in the art.

The control valve 80a is adapted to receive charge pressure from the charge pump 215 via a fluid conduit 238 and deliver the pump control pressure to the pump controller 228a in response to the magnitude of the control signal produced by the microprocessor 22. The pump controller 228a receives the pump control pressure and adjusts the position of the swash plate 235a in response to the control pressure. For this purpose, the pump controller 228a includes a hydromechanical servo valve 240a in fluid communication with the control valve 80a and for receiving the pump control pressure. When a forward control signal is applied to the forward solenoid 82a,

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a control pressure proportional to the forward signal is communicated to the servo valve 240a via a forward fluid conduit 241a. Similarly, when a reverse control signal is applied to the reverse solenoid 84a, a  
5 control pressure proportional to the reverse control signal is communicated to the servo valve 240 via a reverse fluid conduit 242a.

The servo valve 240a is mechanically coupled to a three-position hydromechanical valve 245a having  
10 a mechanical feedback means 250a. The valve 245a is normally positioned at a neutral position (N) and is movable to forward (F) and reverse (R) positions by the servo valve 240a. The hydromechanical valve 245a is fluidly coupled to the fluid conduit 238 for  
15 receiving the charge pressure. The valve 245a delivers the charge pressure to a swash plate actuator 255a to move the swash plate 235a in a direction and to a displacement responsive to the control signal applied to the control valve 80a.

20 More specifically, movement of the servo valve 240a mechanically shifts the position of the hydromechanical valve 245a to either the forward or reverse positions F,R. This in turn causes charge pressure to be delivered to the swash plate actuator  
25 255a in a direction corresponding to the position of the valve 245a. When the swash plate 235a reaches the desired position, as indicated by the pump control pressure, the mechanical feedback means 250a moves the hydromechanical valve 245a to the neutral position  
30 (N), thereby stopping flow of the charge pressure to the swash plate actuator 255a.

The pump 225a has forward and reverse ports 260a,263a which are connected to respective forward and reverse ports 265a,268a on the first motor 212a by  
35 fluid conduits 270a,275a, respectively. Since the

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first and second motor systems 210a,b are identical, only the first motor system 210a will be explained. The motor system 210a includes a pilot actuated purge valve 280a connected between the fluid conduits 270a, 275a for connecting the motor port 265a,268a of lower pressure to tank. A relief valve 285a is connected between the purge valve 280a and system tank for preventing operation of the purge valve 280a below a preselected pressure, as would be apparent to one skilled in the art.

The first motor system 210a further includes a drive motor servo valve 305a for controlling displacement of the fluid motor 212a. The motor servo valve 305a is fluidly coupled to the conduit 238 for receiving the charge pressure. The servo valve 305a is also fluidly coupled to a check valve 310a via a fluid conduit 312a for receiving a pilot pressure which is proportional to the pump control pressure. The latter function is accomplished by connecting the check valve 310a between control valve 80 and the servo valve 240a. The servo valve 305a delivers a motor control pressure to a pump actuator 315a which mechanically adjusts the motor displacement in response to the received pressure, as would be apparent to one skilled in the art.

The sync valve 94 is connected between the first and second pump units 225a,b and is adapted to controllably connect and disconnect the pump units 225a,b to control fluid flow therebetween. More specifically, the sync valve 94 has first and second forward ports 330a,b which are connected to the first and second forward fluid conduits 270a,b. The sync valve 94 also has first and second reverse ports 335a,b which are connected to the first and second reverse fluid conduits 272a,b. The sync valve 94 is

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normally biased to a first position, as shown, at which communication between the first and second pump units 225a,b is blocked. The sync valve 94 is movable to a second position in response to a sync signal  
5 which is produced by the microprocessor 22. When the sync valve 94 is at the second position, interflow of hydraulic fluid between the first and second pump units 225a,b is permitted, thereby synchronizing the speeds of the first and second motors 212a,b.

10 The microprocessor 22 is programmed to deliver the sync signal when rectilinear vehicle travel is desired. If steering operations are desired, as indicated by the presence of left or right steering signals, the sync signal is not produced and,  
15 hence, the sync valve 94 is positioned at the first position.

Referring now to Figs. 4 and 5, embodiments of software for programming the controller in accordance with certain aspects of the immediate  
20 invention is explained. Figs. 4 and 5 are flowcharts illustrating a computer software program for implementing the preferred embodiment of the present invention. Specifically, Fig. 4 illustrates a software program which can be used in connection with  
25 the above-described hydrostatic drive system 200, or alternatively in connection with an engine controller. Fig. 5 illustrates a software program which can be used in conjunction with a transmission controller. The programs depicted in these flowcharts are  
30 particularly well adapted for use with the microprocessor and associated components described above, although any suitable microprocessor may be utilized in practicing an embodiment of the present invention. These flowcharts constitute complete and  
35 workable design of the preferred software programs.

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The software programs may be readily coded from these detailed flowcharts using the instruction set associated with this system, or may be coded with the instructions of any other suitable conventional  
5 microprocessors. The process of writing software code from flowcharts such as these is a mere mechanical step for one skilled in the art.

Referring now specifically to Fig. 4, a flowchart illustrating a computer program which can be  
10 used in connection with the hydrostatic drive system of Figs. 2 and 3A-B or with an engine controller will be described.

Initially, in the block 200 the parameter signals are read from the various sensor means 23 and  
15 the control members 19. Control is then passed to the block 210 where diagnostics are performed on the parameter signals to determine if undesirable operating conditions exist. As stated above, the present invention is not limited to any particular  
20 diagnostic tests; therefore, specific diagnostic tests are not disclosed herein.

Next, in the block 220 the undesirable operating conditions, including detected faults of the electronic control system itself, are classified in  
25 accordance with a preselected strategy. More particularly, each detected undesirable operating condition is classified into one of the four severity levels in response to the criticality of an undesirable operating condition. It should be  
30 understood that a given undesirable operating condition may be classified at any one of the severity levels in dependance on the criticality of the detected fault. For example, safe engine operating temperatures could range between 25°C and 100°C.  
35 While warning levels D, C, B and A could correspond

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respectively to temperatures of 101-110°C, 111-120°C, 121-130°C, and greater than 130°C. This process is repeated for all the detected undesirable operating conditions.

5                   Thereafter, control is passed to the block 240. Since more than one undesirable operating condition may be present at a given instance of time, the diagnostic means 24 determines the highest severity level for which an undesirable operating  
10 condition presently exists and produces a severity level signal in response to the highest detected severity level. This function is performed in the decision blocks 240, 250, 260 and 270. More specifically, in the block 240 it is determined if any  
15 faults of severity level A exist. If a severity level A fault is detected in the block 240, control is passed to the block 245. In the block 245 a shutdown factor SF is set to a preselected value. In the preferred embodiment, the shutdown factor is set to  
20 0.0 if any severity level A faults exist.

                  If no severity level A faults are detected, control is passed to the decisions block 250 where it is determined if any severity level B faults are present. Similar tests are performed in the blocks  
25 260 and 270 to detect the presence of faults having severity levels C and D, respectively. If severity levels B, C, or D are detected, the shutdown factor SF is set to preselected values in the blocks 255, 265 and 270, respectively. As should be apparent, the  
30 arrangement of the decisions blocks 240-270 ensures that the shutdown factor is selected in response to the highest detected severity level.

                  After the steps 240-275 are executed, control is passed to the block 280 where the value of  
35 the control signal is modified in response to the

-22-

value of the shutdown factor SF. More specifically, the value of the control signal is multiplied by the value of the shutdown factor SF, thereby limiting the control signal to a preselected percentage of its maximum value. Different values of the shutdown factor SF are selected for each of the severity levels such that the maximum allowable speed of the vehicle is reduced as the detected severity levels increase. These values are illustrated as 0.0 for level A, 0.3 for level B, 0.5 for level C and 1.0 for level D. It should be understood that these values are purely illustrative and are not limitations on the present invention. Moreover, it should be noted that in the case of the hydrostatic drive circuit 200 discussed above, the control signal actually consists of the first and second control signals. The control signal is delivered to the vehicle drive system to control the speed of the vehicle. In this manner, the maximum speed of the vehicle can be limited in response to the most severe fault.

As was stated above, Fig. 4 can also be used in connection with an engine controller. In such an application, the program of Fig. 4 is used to modify an engine speed control signal. More particularly, the shutdown factor SF is multiplied with the value of an engine speed control signal such as a throttle control signal or a fuel injection rate signal. In this manner, the engine speed is limited in response to the most severe fault.

In still another embodiment, the program of Fig. 4 can be used to modify the desired speed signal as is input from the S/D lever or an accelerator pedal, for example. In such an embodiment, the steps 200-275 are identical to those illustrated in Fig. 4. The value of the desired speed signal is then modified

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by the value of the shutdown factor in the block 280. More specifically, the control is programmed to multiply the desired speed signal by the shutdown factor, thereby limiting the maximum value of the  
5 desired speed signal to a preselected percentage of its maximum. Modification of the desired speed signal in this manner has essentially the same effect as modifying the control signal.

Referring now to Fig. 5, still another  
10 embodiment of the present invention will be discussed. Fig. 5 illustrates software to be used in connection with the diagnostic means 24 and a transmission controller. Inasmuch as transmission controllers are well known in the art, no description of such devices  
15 is provided herein. Essentially, the steps 300-370 parallel the steps 200-270 of Fig. 4. In the blocks 345, 355, 365 and 370, the control is programmed to select a maximum allowable gear ratio in response to the highest detected severity level. As can be seen,  
20 higher severity levels result in slower maximum gear ratios. More specifically, the maximum allowable gear is set to first, second, third and fourth in response to severity levels A, B, C, D, respectively. In this manner, the maximum allowable ground speed can be  
25 controlled as a function of the highest detected severity level.

Control is then passed to the block 380 where it is determined if the actual transmission gear ratio is less than or equal to the maximum allowable  
30 gear ratio. If it is not, control is passed to the block 385 where the transmission is controllably downshifted to the maximum allowable gear.

35

Industrial Applicability

Assume that the apparatus 10 is installed on a vehicle such as a track type loader. The vehicle is equipped with a plurality of sensors 24 for sensing vehicle parameters and producing respective parameter signals. The parameter signals and various control signals are delivered to the microprocessor 22. The microprocessor 22 processes the received signals to detect undesirable operating conditions.

The microprocessor 22 continuously processes the received signals to detect undesirable operating conditions. As long as no faults are detected, the vehicle is allowed to operate at its maximum capacity. However, if undesirable operating conditions are detected, each detected undesirable operating condition is classified into one of the severity levels in accordance with its severity. The microprocessor 22 then determines the highest severity level for which an undesirable operating condition exists and responsively produces a severity level signal. The severity level signal is delivered to the controller means which produces a shutdown factor in response to the severity level signal. For example, if the severity level signal corresponds to level B, the shutdown factor is set to 0.3. The microprocessor 22 then limits the speed of the vehicle to 30% of the operator requested value by multiplying the control signal times the shutdown factor. In this manner, the maximum speed of the vehicle is limited as a function of the severity of detected vehicle faults.

Other aspects, objects, and advantages of the present invention can be obtained from a study of the specification, drawings, and appended claims.

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Claims

1. A method for controlling a vehicle equipped with a drive system (12), a controller means (16) for regulating the operating speed of the drive system and a diagnostic means (24) for sensing at least one operating parameter and responsively diagnosing undesirable operating conditions, comprising steps of:
- 10                   processing the parameter signal to detect if an undesirable operating condition exists;
- determining a severity level of a detected undesirable operating condition in accordance with a predetermined strategy, and
- 15                   limiting the maximum speed of the vehicle in response to the determined severity level, whereby the maximum allowable vehicle speed decreases as the severity level increases.
- 20                   2. A method as set forth in claim 1 wherein the speed of the vehicle is controlled in response to a control signal and wherein the magnitude of the control signal is limited in response to the severity level.
- 25                   3. A method as set forth in claim 2, further including the steps of:
- classifying the detected undesirable operating condition into one of a preselected number of hierarchical severity levels; and
- 30                   limiting the magnitude of the control signal in response to the highest severity level for which an undesirable operating condition presently exists.

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4. A method as set forth in claim 3 wherein the step of limiting the magnitude of the control signal includes multiplying the control signal by a shutdown factor, wherein a different shutdown factor is selected for each of the hierarchical severity levels.

5. A method as set forth in claim 4 wherein the control signal controls engine speed.

6. A method as set forth in claim 4 wherein the vehicle includes a hydrostatic drive system (200) having at least one hydraulic motor (212) which is controlled in response to the control signal.

7. A method as set forth in claim 1 wherein the vehicle includes a transmission having a plurality of gear ratios and the maximum allowable gear ratio is limited in response to the severity of a detected fault.

8. A method as set forth in claim 7 further comprising the steps of:  
classifying the detected undesirable operating condition into one of a preselected number of hierarchical severity levels; and  
limiting the maximum allowable gear ratio to a different gear ratio in each of the severity levels.

9. A method as set forth in claim 1 wherein the speed of the vehicle is controlled in response to a desired speed signal and the step of limiting the speed of the vehicle includes limiting the magnitude of the desired speed signal in response to the detected severity level, whereby as the value of the

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desired speed signal is reduced as the detected severity level increases.

10. A method as set forth in claim 9,  
5 further including the steps of:  
classifying the detected undesirable  
operating condition into one of a preselected number  
of hierarchical severity levels; and  
10 limiting the magnitude of the desired speed  
signal in response to the highest severity level for  
which an undesirable operating condition presently  
exists.

11. A method as set forth in claim 10  
15 wherein the step of limiting the magnitude of the  
desired speed signal includes multiplying the desired  
speed signal by a shutdown factor, wherein a different  
shutdown factor is selected for each of the  
hierarchical severity levels.

20  
12. A method as set forth in claim 1,  
further including the steps of:  
classifying the detected undesirable  
operating condition into one of a preselected number  
25 of hierarchical severity levels; and  
limiting the maximum speed of the vehicle in  
response to the highest severity level for which an  
undesirable operating condition presently exists.

30 13. A method for controlling a vehicle  
equipped with a drive system (12), a controller means  
(16) for regulating the operating speed of the drive  
system (12) and a diagnostic means (24) for sensing a  
plurality of operating parameter and responsively

35

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diagnosing faulty operating conditions, comprising steps of:

- 5 processing each of the parameter signals to determine if the associated sensed parameter is in an undesirable operating condition;
- determining the severity level of each detected undesirable operating condition in accordance with a preselected strategy,
- 10 determining the highest severity level which presently exists; and
- limiting the maximum speed of the vehicle in response to the highest severity level, whereby the maximum vehicle speed decreases as the severity level increases.

15

14. A method as set forth in claim 13 wherein the speed of the vehicle is controlled in response to a control signal and wherein the magnitude of the control signal is limited in response to the severity level.
- 20

15. A method as set forth in claim 14, further including the steps of:

- 25 classifying each detected undesirable operating condition into one of a preselected number of hierarchical severity levels; and
- limiting the magnitude of the control signal in response to the highest severity level for which an undesirable operating condition presently exists.

30

16. A method as set forth in claim 15 wherein the step of limiting the magnitude of the control signal includes multiplying the control signal by a shutdown factor, wherein a different shutdown

35

factor is selected for each of the hierarchical severity levels.

5 17. A method as set forth in claim 16 wherein the control signal controls engine speed.

10 18. A method as set forth in claim 16 wherein the vehicle includes a hydrostatic drive system (200) having at least one hydraulic motor (212) which is controlled in response to the control signal.

15 19. A method as set forth in claim 13 wherein the vehicle includes a transmission having a plurality of gear ratios and the maximum allowable gear ratio is limited in response to the severity of a detected fault.

20 20. A method as set forth in claim 19 further comprising the steps of:  
classifying each detected undesirable operating condition into one of a preselected number of hierarchical severity levels; and  
limiting the maximum allowable gear ratio to a different gear ratio in each of the severity levels.

25 21. A method as set forth in claim 13 wherein the speed of the vehicle is controlled in response to a desired speed signal and the step of limiting the speed of the vehicle includes limiting  
30 the magnitude of the desired speed signal in response to the detected severity level, whereby as the value of the desired speed signal is reduced as the detected severity level increases.

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22. A method as set forth in claim 21,  
further including the steps of:

5 classifying the detected undesirable  
operating condition into one of a preselected number  
of hierarchical severity levels; and

limiting the magnitude of the desired speed  
signal in response to the highest severity level for  
which an undesirable operating condition presently  
exists.

10

23. A method as set forth in claim 22  
wherein the step of limiting the magnitude of the  
desired speed signal includes multiplying the desired  
speed signal by a shutdown factor, wherein a different  
15 shutdown factor is selected for each of the  
hierarchical severity levels.

24. A method as set forth in claim 13,  
further comprising the steps of:

20 classifying the detected undesirable  
operating condition into one of a preselected number  
of hierarchical severity levels; and

limiting the maximum speed of the vehicle in  
response to the highest severity level for which an  
25 undesirable operating condition presently exists.

25. An apparatus (10) for a vehicle  
equipped with a drive system (12) and a controller  
means (16) for regulating the operating speed of the  
30 drive system:

at least one sensor means (23) for sensing a  
vehicle parameter and producing a parameter signal in  
response to the sensed parameter;

35 diagnostic means (24) for receiving the  
parameter signal, processing the signal to detect the

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presence of an undesirable operating condition;  
determining the severity of the undesirable operating  
condition in accordance with a preselected strategy  
and responsively producing a severity level signal;  
5 and

wherein the controller means (16) receives  
the severity level signal and limits the maximum speed  
of the vehicle in response to the severity level  
signal, whereby the maximum allowable vehicle speed  
10 decreases as the severity level signal increases.

26. An apparatus (10) as set forth in claim  
25 wherein the controller means (16) produces a  
control signal which controls the speed of the vehicle  
15 and wherein the controller means (16) limits the  
magnitude of the control signal in response to the  
severity level signal.

27. An apparatus (10) as set forth in claim  
20 26, wherein the diagnostic means (24) further  
classifies the detected undesirable operating  
condition into one of a preselected number of  
hierarchical severity levels and responsively produces  
a corresponding severity signal.

25  
28. An apparatus (10) as set forth in claim  
27 wherein the controller means (16) receives the  
severity signal, produces a shutdown factor in  
response to the severity level signal and multiplies  
30 the control signal by a shutdown factor, wherein a  
different shutdown factor is selected for each of the  
value of the severity signal.

29. An apparatus (10) as set forth in claim  
35 28 wherein the control signal controls engine speed.

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30. An apparatus as set forth in claim 28 wherein the vehicle includes a hydrostatic drive system (200) having at least one hydraulic motor (212) which is controlled in response to the control signal.

31. An apparatus (10) as set forth in claim 25 wherein the vehicle includes a transmission having a plurality of gear ratios, a transmission controller controlling operation of the transmission in response to sensed vehicle parameters, and wherein the transmission controller is adapted to limit the maximum allowable gear ratio is limited in response to the severity of a detected fault.

15

32. An apparatus (10) as set forth in claim 31, wherein the diagnostic means further classifies the detected undesirable operating condition into one of a preselected number of hierarchical severity levels and responsively produces a corresponding severity signal; and

wherein the transmission controller is adapted to receive the severity level signal and limit the maximum allowable gear ratio to a different gear ratio in each of the severity levels.

33. An apparatus (10) as set forth in claim 32 wherein the controller means (16) is adapted to receive a desired speed signal and responsively produce a control signal for controlling the speed of the vehicle, and wherein the controller means (16) receives the severity signal and limits the magnitude of the desired speed signal in response to the magnitude of the severity signal, whereby as the value

35

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of the desired speed signal is reduced as the severity signal increases.

5           34. An apparatus (10) as set forth in claim  
33, wherein the diagnostic means (22) further  
classifies the detected undesirable operating  
condition into one of a preselected number of  
hierarchical severity levels and responsively produces  
a corresponding severity signal.

10

          35. An apparatus (10) as set forth in claim  
34 wherein the controller means (16) receives the  
severity signal, produces a shutdown factor signal in  
response to the severity level signal and multiplies  
15 the desired speed signal by the shutdown factor  
signal, wherein a different shutdown factor is  
selected for each of the value of the severity signal.

          36. An apparatus (10) as set forth in claim  
20 25, wherein the diagnostic means (22) further  
classifies the detected undesirable operating  
condition into one of a preselected number of  
hierarchical severity levels and responsively produces  
a corresponding severity signal.

25

          37. An apparatus (10) for a vehicle  
equipped with a drive system (12) and a controller  
means (16) for regulating the operating speed of the  
drive system (12), comprising:

30           a plurality of sensor means (23) for sensing  
vehicle parameters and responsively producing  
respective parameter signals;

          diagnostic means (24) for receiving the  
parameter signals, processing the parameter signals to  
35 detect the presence of an undesirable operating

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conditions; determining a severity level for each detected undesirable operating condition in accordance with a preselected strategy; determining the highest severity level for which an undesirable operating condition presently exists and producing a severity level signal in response to the highest detected severity level; and

5  
10 wherein the controller means (16) receives the severity level signal and limits the maximum speed of the vehicle in response to the severity level signal, whereby the maximum allowable vehicle speed decreases as the severity level signal increases.

15 38. An apparatus (10) as set forth in claim 37, wherein the controller means (16) produces a control signal which controls the speed of the vehicle and wherein the controller means (16) limits the magnitude of the control signal in response to the severity level signal.

20 39. An apparatus (10) as set forth in claim 38, wherein the diagnostic means (24) further classifies the detected undesirable operating condition into one of a preselected number of hierarchical severity levels and responsively produces a corresponding severity signal.

30 40. An apparatus (10) as set forth in claim 39, wherein the controller means (16) receives the severity signal, produces a shutdown factor in response to the severity level signal and multiplies the control signal by a shutdown factor, wherein a different shutdown factor is selected for each of the value of the severity signal.

35

41. An apparatus (10) as set forth in claim 40, wherein the control signal controls engine speed.

42. An apparatus (10) as set forth in claim 5 40, wherein the vehicle includes a hydrostatic drive system (200) having at least one hydraulic motor (212) which is controlled in response to the control signal.

43. An apparatus (10) as set forth in claim 10 37, wherein the vehicle includes a transmission having a plurality of gear ratios, a transmission controller controlling operation of the transmission in response to sensed vehicle parameters, and wherein the transmission controller is adapted to limit the 15 maximum allowable gear ratio is limited in response to the severity of a detected fault.

44. An apparatus (10) as set forth in claim 20 43, wherein the diagnostic means (24) further classifies each detected undesirable operating condition into one of a preselected number of hierarchical severity levels and responsively produces a severity signal corresponding to the highest detected severity level; and

25 wherein the transmission controller is adapted to receive the severity signal and limit the maximum allowable gear ratio to a different gear ratio in each of the severity levels.

30 45. An apparatus (24) as set forth in claim 44, wherein the controller means (16) is adapted to receive a desired speed signal and responsively produce a control signal for controlling the speed of the vehicle, and wherein the controller means (16) 35 receives the severity signal and limits the magnitude

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of the desired speed signal in response to the magnitude of the severity signal, whereby as the value of the desired speed signal is reduced as the severity signal increases.

5

46. An apparatus (10) as set forth in claim 45, wherein the diagnostic means (24) further classifies each detected undesirable operating condition into one of a preselected number of hierarchical severity levels and produces the severity signal in response to the highest detected severity level.

47. An apparatus (10) as set forth in claim 46, wherein the controller means (16) receives the severity signal, produces a shutdown factor signal in response to the severity level signal and multiplies the desired speed signal by the shutdown factor signal, wherein a different shutdown factor is selected for each of the value of the severity signal.

48. An apparatus (10) as set forth in claim 37, wherein the diagnostic means (24) further classifies each detected undesirable operating condition into one of a preselected number of hierarchical severity levels and produces a severity signal corresponding to the highest detected severity level.

49. An apparatus (10) for a vehicle equipped with a hydrostatic drive system (200), the drive system (200) including first and second hydrostatic transmissions, each hydrostatic transmission including a fluid pump (230) driven by an engine (50) and being responsive to a respective

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control signal to provide pressurized fluid in proportion thereto and a motor (212) connected to the pump (230) and being driven by the pressurized fluid, the drive system (200) further includes controller means (16) for producing the control signals, comprising:

a plurality of sensor means (23) for sensing vehicle parameters and responsively producing respective parameter signals;

diagnostic means (24) for receiving the parameter signals, processing the parameter signals to detect the presence of undesirable operating conditions; determining the severity level of each detected undesirable operating conditions in accordance with a preselected strategy; determining the highest severity level for which an undesirable operating condition presently exists and producing a severity level signal in response to the highest detected severity level; and

wherein the controller means (16) receives the severity level signal and limits the magnitude of the control signals in response to the severity level signal, whereby the maximum allowable value of the control signal decreases as the severity level signal increases.

50. An apparatus (10) for a vehicle equipped with a hydrostatic drive system (200), the drive system (200) including first and second hydrostatic transmissions, each hydrostatic transmission including a fluid pump (230) driven by an engine (50) and being responsive to a respective control signal to provide pressurized fluid in proportion thereto and a motor (212) connected to the pump (230) and being driven by the pressurized fluid,

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the drive system (200) further including a controller means (16), comprising:

a plurality of sensor means (23) for sensing vehicle parameters and responsively producing  
5 respective parameter signals;

diagnostic means (24) for receiving the parameter signals, processing the parameter signals to detect the presence of undesirable operating conditions; classifying the detected undesirable  
10 operating conditions into one of a preselected number of hierarchical severity levels, determining the highest severity level for which an undesirable operating condition presently exists and producing a severity signal corresponding to the highest detected  
15 severity level; and

wherein the controller means (16) receives the severity level signal and limits the magnitude of the control signals in response to the severity level signal, whereby the maximum allowable value of the  
20 control signal decreases as the severity level signal increases.

25

30

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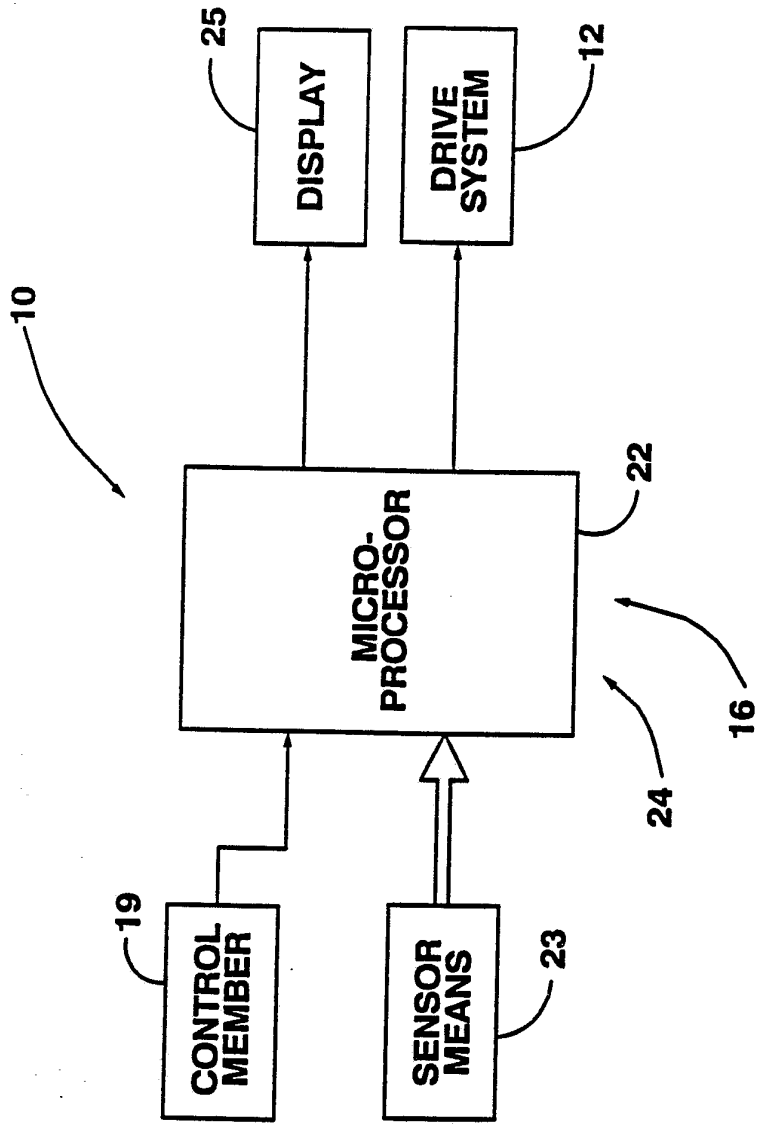


FIG. 1-

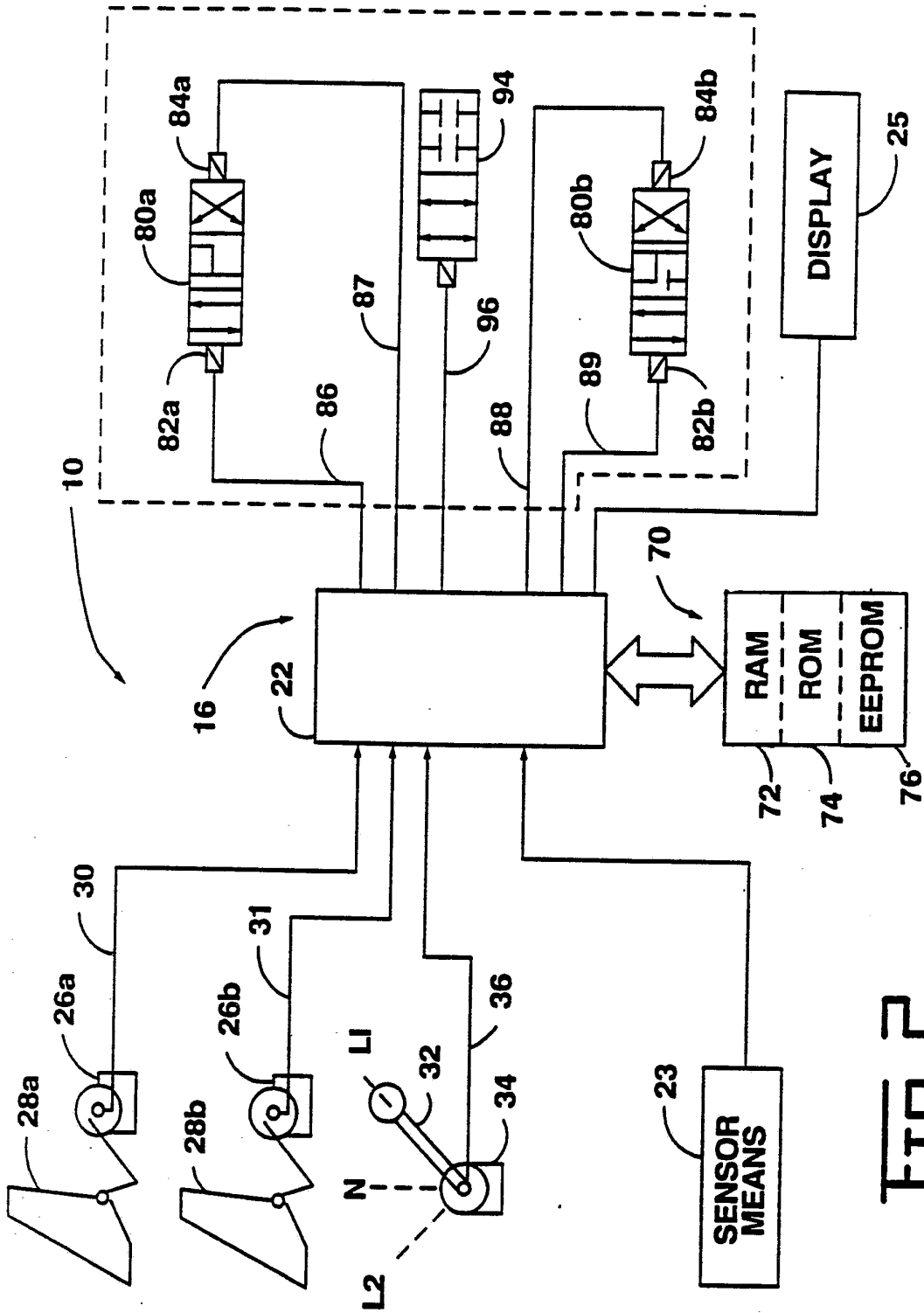


FIG. 2

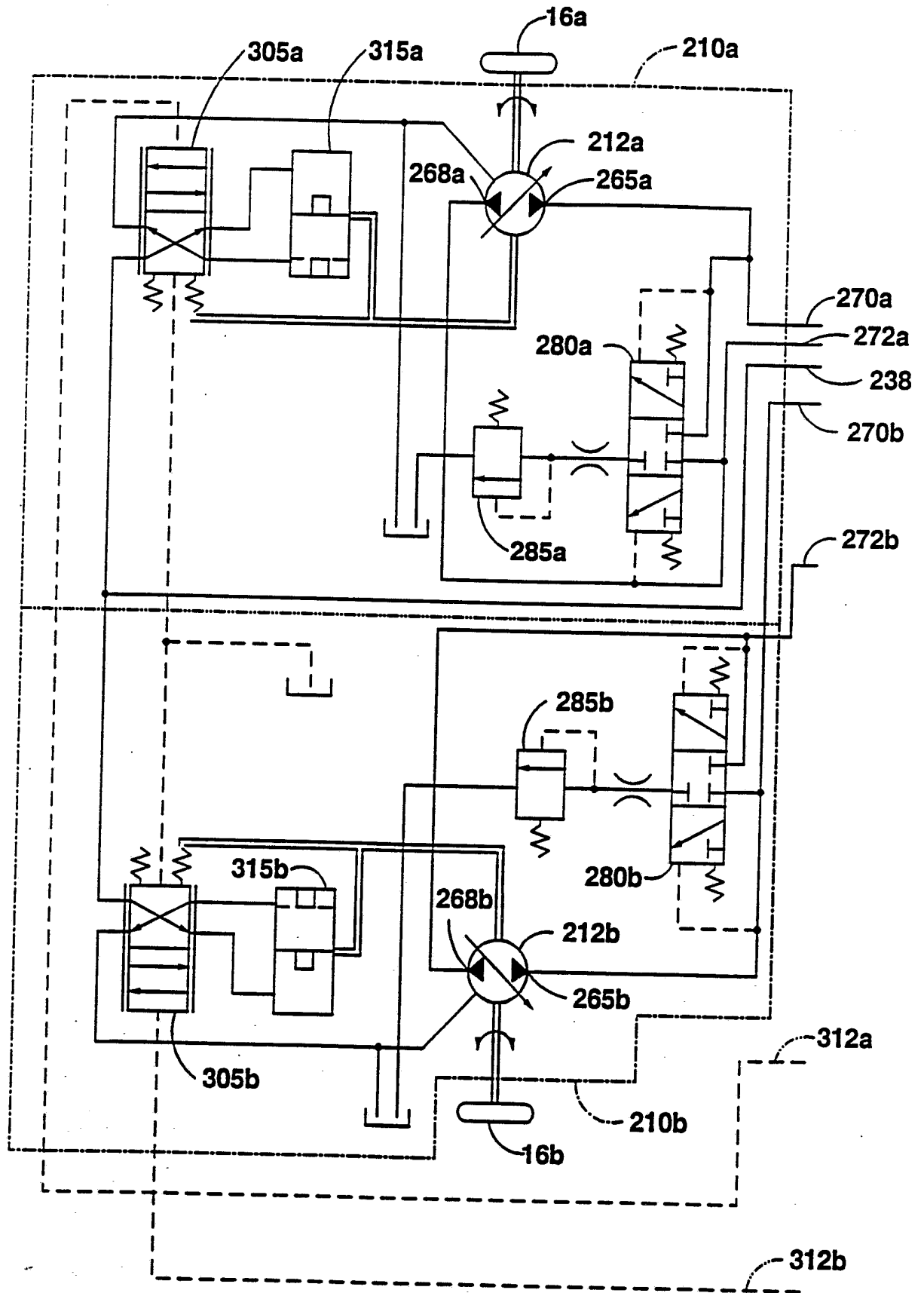
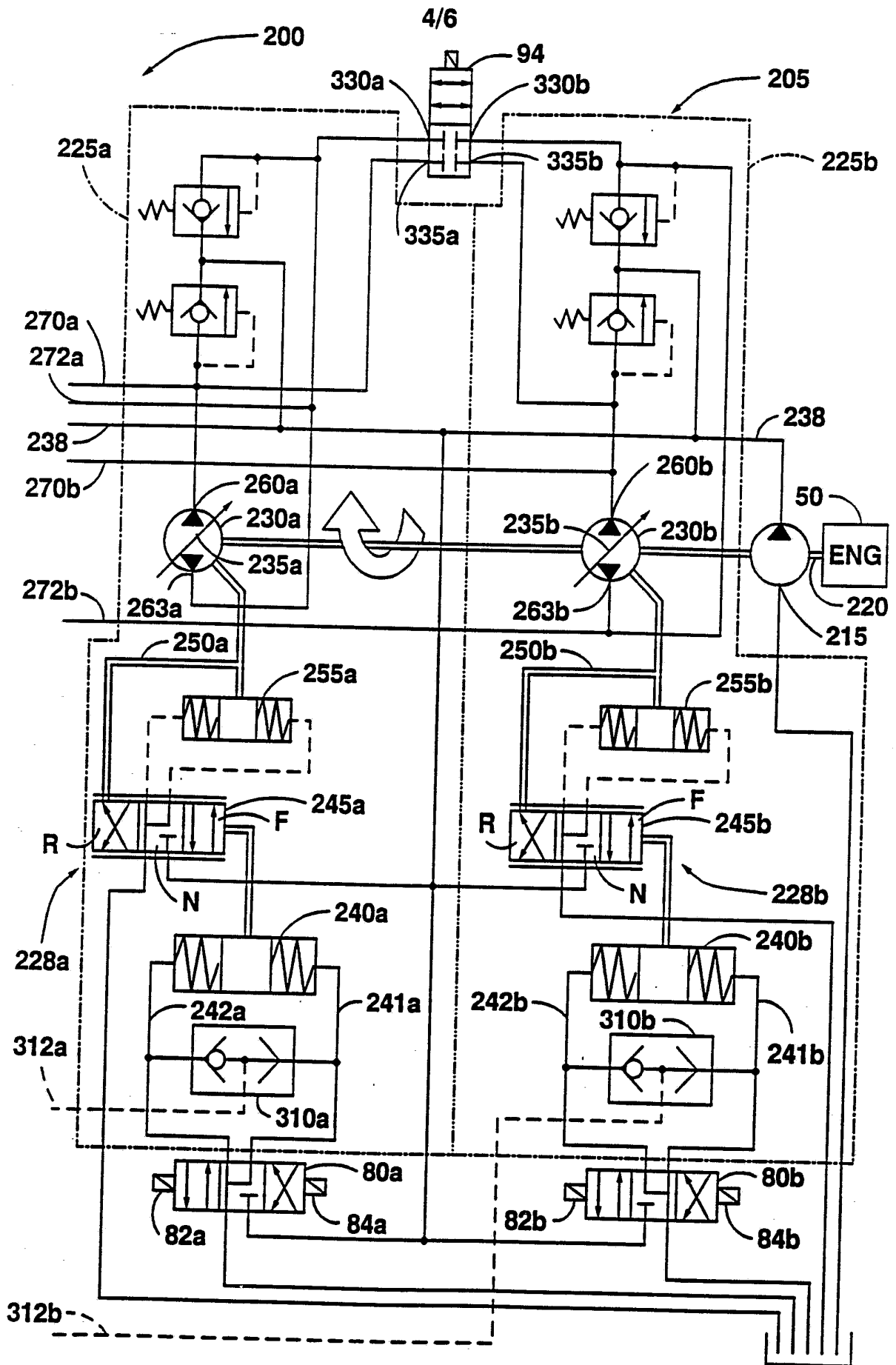


FIG. 3A



**FIG. 3B**

FIG. 4.

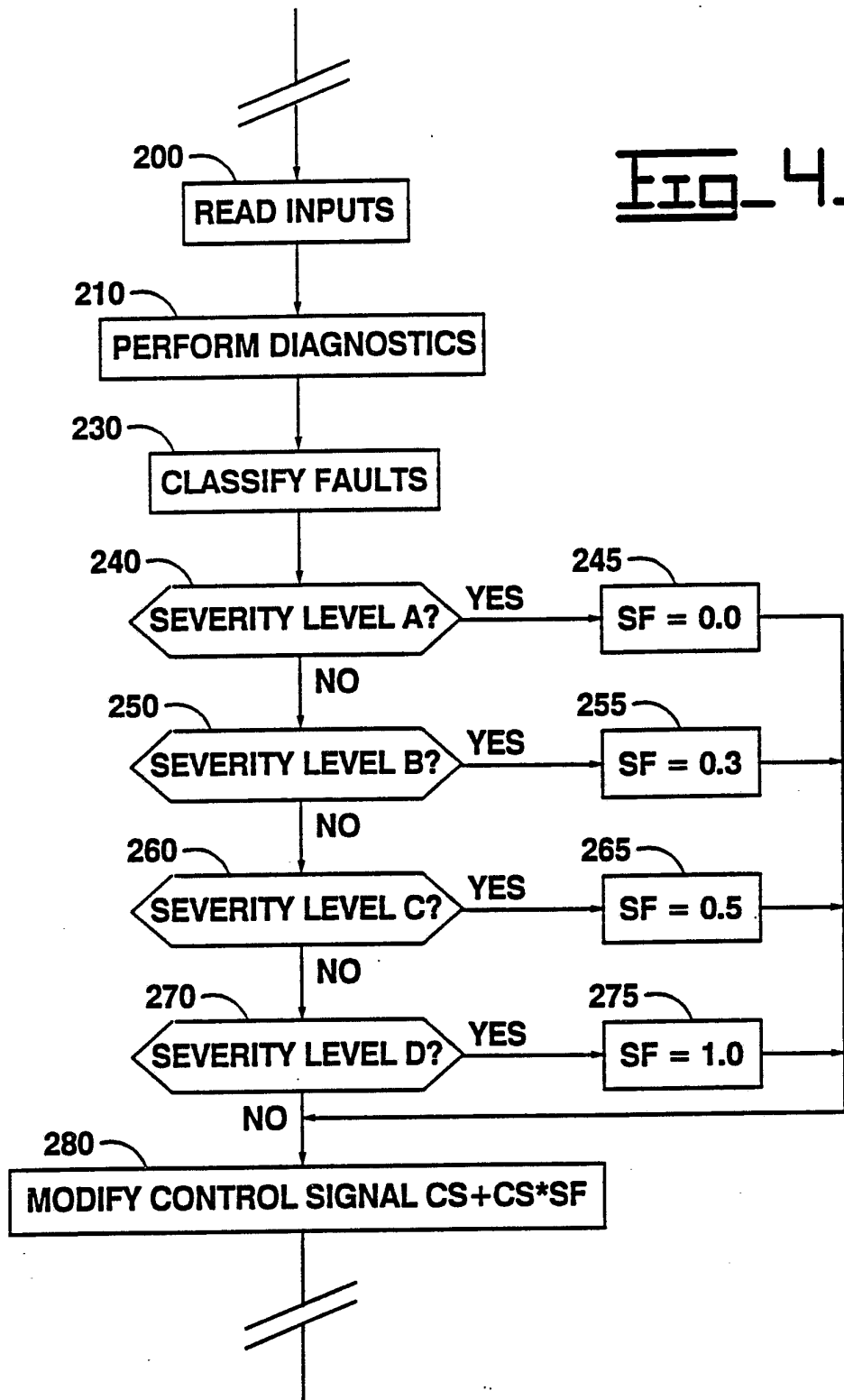
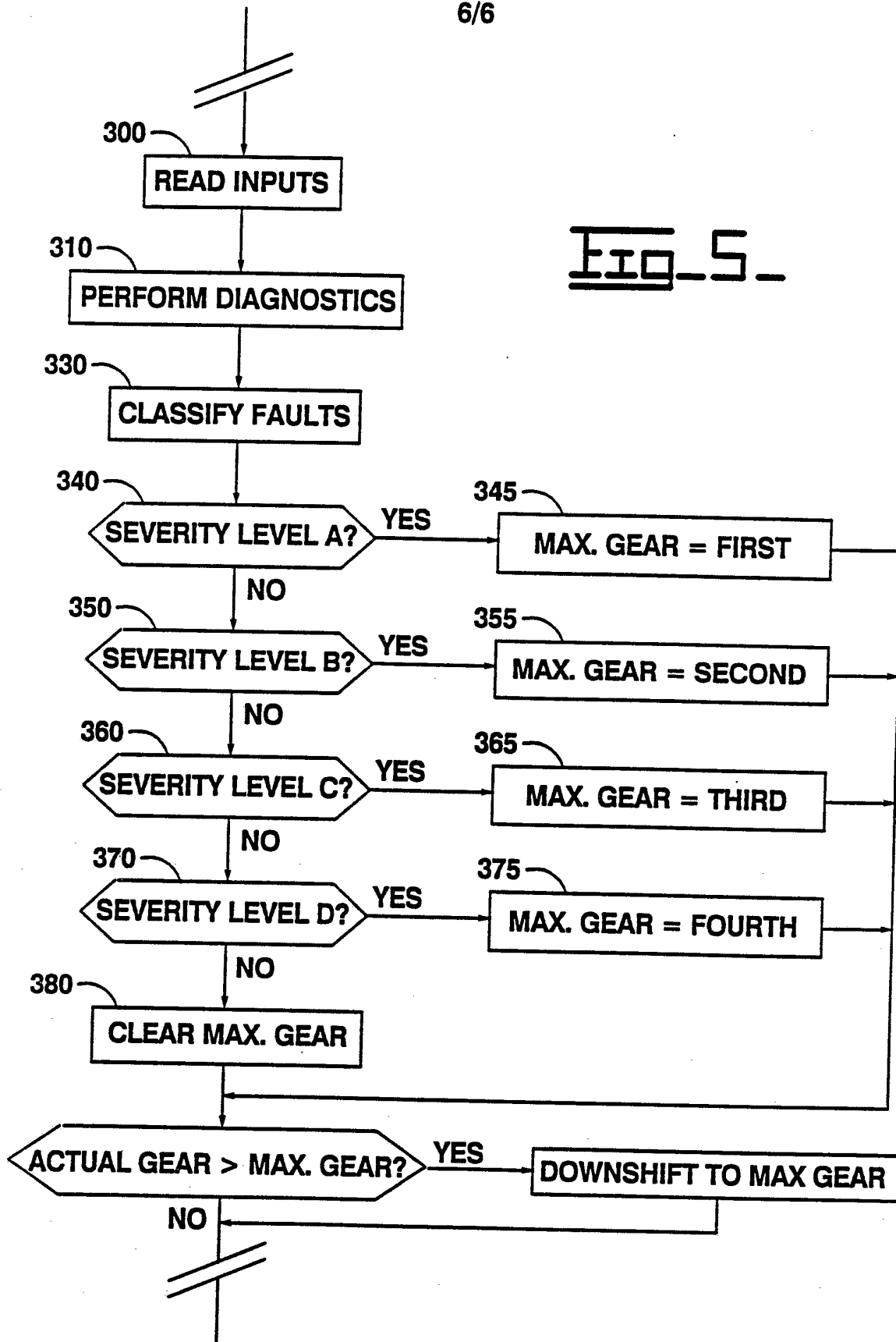


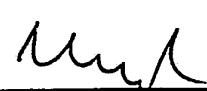
FIG. 5.



## INTERNATIONAL SEARCH REPORT

PCT/US 91/09742

International Application No

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 F16H61/12; G07C5/08		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl. 5	G07C ; B60K ; F16H ; F02D F02B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	US,A,5 070 832 (HAPKA) 10 December 1991 see column 2, line 43 - column 6, line 42 see claims; figures	1-5,9-17 21-29 37-41
Y	---	6-8, 18-20, 30-36, 42-50
Y	WO,A,7 900 679 (BESANT) 20 September 1979 see abstract; claims; figures	6,18,30, 42,49,50
	---	
	--- -/--	
<p><sup>10</sup> Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" 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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"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.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
27 AUGUST 1992	09.09.92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	MEYL D. 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category <sup>o</sup>	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	US,A,4 918 606 (ITO) 17 April 1990	7,8,19, 20, 31-36, 43-48
A	see column 1, line 63 - column 2, line 35 see column 6, line 59 - column 7, line 34; figures	1,13,25, 37,49,50
Y	GB,A,2 062 781 (KOMATSU) 28 May 1981 see abstract; claims; figures	49,50
A	GB,A,2 084 673 (AISIN SEIKI) 15 April 1982 see page 3, line 75 - page 4, line 28; figures	1-50
A	VEHICLE ELECTRONICS IN THE 90'S : PROCEEDINGS OF THE INTERNATIONAL CONGRESS ON TRANSPORTATION ELECTRONICS October 1990, WARRENDALE, PA pages 355 - 362; LIGHT E.A.: 'The Evolution of Electronic Engine Diagnostics' page 361: 'Engine Protection'	1,13,25, 37,49,50
A	EP,A,0 310 275 (SATURN) 5 April 1989	
A	EP,A,0 231 155 (IVECO FIAT) 5 August 1987	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. US 9109742  
SA 57062**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 27/08/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5070832	10-12-91	None	
WO-A-7900679	20-09-79	GB-A- 1600699 EP-A- 0014704	21-10-81 03-09-80
US-A-4918606	17-04-90	JP-A- 63047549	29-02-88
GB-A-2062781	28-05-81	JP-C- 1235419 JP-A- 56053930 JP-B- 59009374 DE-A- 3038400 US-A- 4386688	17-10-84 13-05-81 02-03-84 23-04-81 07-06-83
GB-A-2084673	15-04-82	JP-C- 1475010 JP-A- 57073259 JP-B- 63024189 DE-A, C 3137910 US-A- 4363973	18-01-89 07-05-82 19-05-88 15-04-82 14-12-82
EP-A-0310275	05-04-89	US-A- 4843551 DE-A- 3866324 JP-A- 1158256	27-06-89 02-01-92 21-06-89
EP-A-0231155	05-08-87	JP-A- 62210244	16-09-87