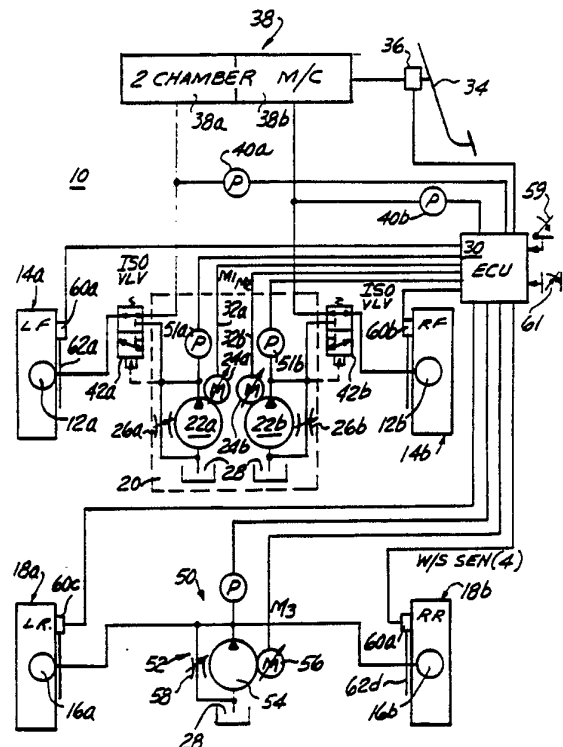




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(54) Title: ELECTROHYDRAULIC BRAKING SYSTEM WITH PUSH THROUGH CAPABILITY (57) Abstract A braking system for front and rear service brakes of a vehicle comprising: first electrohydraulic actuator (20) for pressurizing the front service brakes in response to an electric control signal representative of operator applied braking effort during normal front service braking operation and a master cylinder (38) having first and second chambers (38a, 38b) for pressurizing hydraulic cylinders (12a, 12b) associated with the front service brakes in response to operator applied braking effort. The master cylinder (38) provides brake activation in the event the first electrohydraulic means (20) does not operate. The system additionally includes a plurality of isolation valves (42a, 42b), located upstream of each front brake cylinder (12a, 12b) for selectively communicating fluid pressurized by the master cylinder (38) or fluid pressurized by the first electrohydraulic means (20) to a particular one of such cylinders. A hydraulic actuator (50) is provided for pressurizing the rear service brakes. A control system is included in an ECU (30) for generating control signals to activate various system components.		



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ELECTROHYDRAULIC BRAKING SYSTEM WITH
PUSH THROUGH CAPABILITY

BACKGROUND AND SUMMARY OF THE INVENTION

5 The present invention generally relates to an electrohydraulic braking system for a vehicle and more particularly to a system using a master cylinder in a back-up mode in the event of a failure of the electrohydraulic portion of the system.

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 The present invention defines a brake system for a vehicle in which the primary, normal service brake operation is provided electrohydraulically. More specifically, various hydraulic cylinders of the vehicle
15 brakes are pressurized by a motor driven pump in response to control signals generated by an electronic control unit. Certain brakes (front, rear or both) of the vehicle are provided with a dual means of activation. A master cylinder is used to provide front brake pressure,
20 referred to as "push through" brake pressure, in the event that the electrohydraulic portion of the system is inoperative. The system can be used to provide for normal service braking as well as antilock and traction control as required.

25

 Accordingly the invention comprises: a braking system for front and rear service brakes of a vehicle comprising: first electrohydraulic actuator, for pressurizing the service brakes in response to an
30 electric control signal representative of operator applied braking effort during normal front service braking operation; and a master cylinder preferably

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having first and second chambers for pressurizing service brake or hydraulic cylinders associated with the certain brakes in response to operator applied braking effort. The master cylinder provides brake activation in the event the first electrohydraulic means does not operate. The system additionally includes a plurality of isolation valves, located upstream of each front brake cylinder for selectively communicating fluid pressurized by the master cylinder or fluid pressurized by the first electrohydraulic means to a particular one of such cylinders. A hydraulic actuator is provided for pressurizing the rear service brakes. A control system is included in an ECU for generating control signals to activate various system components. A variety of different embodiments provide for varying degrees of control and provide different types of antilock and traction control of the vehicle wheels.

BRIEF DESCRIPTION OF THE DRAWINGS

20

In the drawings:

FIGURE 1 illustrates a push through type braking system incorporating the features of the present invention.

FIGURE 2 illustrates an alternate embodiment of the present invention.

FIGURE 3 illustrates another embodiment of the present invention.

FIGURE 4 illustrates a further embodiment of the present invention.

FIGURE 5 illustrates an additional embodiment of the present invention.

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FIGURE 6 illustrates an alternative version of an isolation valve.

FIGURE 7 illustrates an alternative valve usable with the present invention.

5 FIGURE 8 illustrates a block diagram of a control circuit for the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

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FIGURE 1 illustrates an electrohydraulic braking system 10 for a vehicle. The braking system includes a plurality of front brake cylinders 12a and 12b associated with the front wheels and brakes generally shown as 14a and 14b. These brake cylinders are shown as hydraulic cylinders. Additional rear brake cylinders 16a and 16b are associated with the rear wheels and brakes 18a and 18b of the vehicle. The brake system 10 includes a first electrohydraulic actuator generally shown as 20. The actuator 20 further includes a plurality of valves generally shown as 26a and 26b which are used to divert a portion of the output flow from its respective pump to a sump generally shown as 28 as well as to provide a means to relieve pressure in the hydraulic cylinders. These valves 26 can be a fixed orifice valve, a mechanical, variable orifice or flow valve which could be piloted by master cylinder pressure, an electric, continuously variable orifice valve, etc. In the embodiment of the invention shown in FIGURE 1, the first electrohydraulic actuator 20 comprises the first and second pumps 22a and 22b powered by first and second motors 24a and 24b. These pumps are preferably unidirectional. Each motor 24a and 24b receives a motor

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control signal generated by an electric control unit (ECU) 30 on line 32a and 32b. The motor control signals M1, M2 are generated in response to operator applied braking effort. The signal indicative of operator applied braking effort P_c , can be obtained by measuring the force imparted by the operator to the brake pedal 34 by a sensor 36, such as a force transducer or alternatively by measuring the hydraulic pressure in each of the chambers 38a and 38b of a two chamber master cylinder generally shown as 38. These pressures can be obtained by using sensors such as pressure sensors 40a and 40b.

The output of master cylinder chamber 38a is communicated to the front brake cylinder 12a through an isolation valve generally shown as 42. Similarly, chamber 38b of master cylinder 38 is communicated to hydraulic cylinder 12b through another isolation valve 42b. In the embodiment of the inventions shown, the isolation valves 42a and 42b are differential force isolation valves. The output of pump 22a is communicated to isolation valve 42a and the output of pump 22b is communicated to isolation valve 42b. It should be appreciated that the master cylinder 38 can include only a single chamber 38a communicated to both isolation valves 42a and 42b. If a single chamber master cylinder is used only one pressure transducer such as 40a is needed.

The rear brakes 18a and 18b and the corresponding hydraulic cylinders 16a and 16b are controlled by a hydraulic actuator generally shown as 50. In this embodiment of the invention, the hydraulic actuator 50

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comprises a second electrohydraulic actuator which is designated as 52. The second electrohydraulic actuator 52 comprises a pump 54, motor 56 and valve 58 of the same construction as the pump, motor and valve used with the front brakes.

The operation of the braking system 10 shown in FIGURE 1 is as follows: each master cylinder chamber 38a and 38b is communicated through the respective isolation valves 42a and 42b to its corresponding brake cylinder 12a and 12b. If a single chamber master cylinder is used, the single chamber such as 38a is communicated to both isolation valves. In response to the motor command signals M1 and M2 the various motors 24a and 24b are activated thereby causing pumps 22a and 22b to develop hydraulic pressure. The method by which the various motor control signals are generated will be described below. The output of each of the pumps 22a and 22b is communicated to a respective isolation valve 42a or 42b. When the pressure generated by a particular pump is greater than the force needed to overcome the spring force of the isolation valve, the isolation valve such as 42a switches to directly communicate the output of the pump to its corresponding brake cylinder such as 12a. When the isolation valve changes its state, the master cylinder 38 is isolated from the front brake cylinders 12a and 12b. As can be appreciated during normal service brake operation, after the isolation valve changes state, the master cylinder 38 is not used to pressurize the brake cylinder 12a and 12b corresponding to the switched isolation valve. The main purpose of the master cylinder 38 is to provide a source of brake pressure to active the brake cylinders 12a and/or 12b in an event of a

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malfunction in the electrohydraulic portion of the system
10. FIGURE 6 illustrates an alternative version of an
isolation valve such as 42' that is referenced to master
cylinder pressure. This valve can be substituted for any
5 other isolation valve.

After the isolation valves 42a and/or 42b change
state the output of the corresponding pump 22a and 22b is
directly communicated to its corresponding front brake
10 cylinder 12a or 12b and provides the only means of
obtaining normal service braking operation.

As mentioned above, the first electrohydraulic
actuator 20 includes a valve such as 26a and 26b. The
15 main purposes of these valves, during service braking,
are to provide a shunt to divert a portion of the pump
flow to the sump 28 as well as to relieve brake cylinder
pressure. During normal service brake operation the
capacity of a particular pump, such as 22a, must be able
20 to fill its corresponding brake cylinder such as 12a as
well as to provide the additional flow through the valve
26a and any internal pump leakage. In this manner a
defined leak path about the pump is provided such that
during normal service brake operation the motor and pump
25 22a and 24a continuously, though slowly rotate to
overcome the objectional effects of motor/pump inertia
and friction thereby improving the response time of the
system. During normal service brake operation, under the
control of the electrohydraulic actuator 20, the pressure
30 Pa, generated in each of the brake cylinders 12a and 12b
is monitored by sensors such as pressure sensors 57a and
57b which are communicated to the ECU and used to modify
the corresponding motor control signals. The use of

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these valves is not absolutely necessary in the present system. The most simple version of an electrohydraulic braking system would eliminate these valves. One advantage of eliminating the valves 26a,b is that size of the pump may be reduced. Having eliminated the valves 26 a means must be provided to communicate the brake cylinders 12 to the sump 28 so that brake pressure can decay when the pump is turned off. This can be achieved by increasing the internal pump leakage paths.

10

As can be appreciated, a slight delay in brake activation may occur in the system 10 due to the time delay in generating the motor control signals M1 and M2 in response to operator applied braking effort and to initially overcome the inertia and friction of the motor/pump. It can be shown that a major component of the delay in actuating an electrohydraulic braking system is primarily due to overcoming friction of the stopped motor/pump. This factor can be eliminated by causing the ECU 30 to generate a low level motor command signal in response to various vehicle parameters in anticipation of brake application. The purpose of this low level motor command signal is to cause the pump 22a and 22b to rotate at a low speed sufficient to overcome its inertia/friction but not sufficient to activate either isolation valves 42a and 42b (or 42'). As an example, normal braking will occur when the operator moves his foot from the accelerator pedal such as 59 and thereafter applies force to the brake pedal. The ECU 30 can monitor the condition of a throttle such as 61 which is indicative of a release, by the operator, of the accelerator pedal 59 or can measure pedal position changes or the force applied to the pedal and thereafter

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generate the above mentioned low level motor control signal. By the time the operator has moved his foot from the accelerator pedal 59 to the brake pedal 34 the pump or pumps in the system 10 will be slowly rotating. In addition, the low level motor control signal can be generated at times corresponding to a low output level of the brake pedal sensor 36 (which is indicative of a very lightly applied brake force) or by monitoring the output of a brake light switch 36' which is also typically activated at very low levels of brake pedal force. Subsequently the individual motors 24a and 24b are controlled in the normal manner such that the pressure generated in the individual front cylinders 12a and 12b is in direct correspondence to operator applied braking effort.

The operation of the second hydraulic actuator 52 and its pump 54, motor 56 and valve 58 is substantially identical to corresponding components in the first electrohydraulic actuator 20. As is known in the art, the magnitude of the commanded brake pressure communicated to the rear brakes is substantially less than that communicated to the front brakes. In normal hydraulic brake systems a mechanical proportioning valve of known construction is utilized to scale the commanded rear brake pressure to be a certain percentage of front brake pressure to account for the differences in the front-rear vehicle loading. In the present invention, it is contemplated that the rear motor command signal M3 will be electronically scaled in the ECU 30 to provide for the front-rear proportioning.

Reference is again made to FIGURE 1. As shown

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therein various valves 26a and 26b and 28 are connected to the output of the respective pumps 22a, 22b and 54. These valves can either be fixed orifices or can be a continuously variable orifice valve. The use of either
5 of these types of valves permit the system 10 to operate in an antilock braking mode of operation with only the inclusion of a wheel speed sensor generally shown as 60a-d and corresponding tone wheels 62a-d. During normal service brake operation various valves 26a, 26b and 58
10 are controlled to present a minimum flow orifice sufficient to permit the pump to continuously rotate to compensate for the fluid communicated to the sump through these valves. Various methods of determining whether a particular wheel or set of wheels is in a skidding or
15 impending skidding condition are well known in the art and will not be discussed herein.

When the ECU 30 determines that any of the vehicle wheels are in a skid or impending skid condition, the
20 following corrective action will take place. Under the control of the ECU 30 the appropriate motor control signal M1-M3 is reduced thereby reducing the pressure supplied to the wheel cylinder to the skidding wheel by the pump such as 22a. The output of pump 22a as
25 measured by pressure sensor such as 57a will be controlled to first permit the skidding wheel to accelerate due to a reduction in pump pressure. As appropriate the ECU will vary the motor control signal such as M1 to reapply the brakes by increasing its speed
30 or to decay the brakes by lessening its speed in correspondence with the desired control algorithm stored within the ECU. Pressure will decay through the valve(s) 26. In addition, if valves 26a,b and 58 are electrically

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controllable, continuously variable orifice valves, then if the pressure within the brake cylinder such as 12a of the skidding wheel does not reduce rapidly enough the ECU will generate a control signal to such valve causing same to increase its flow area permitting the hydraulic cylinder pressure to dump the pressure rapidly to the sump 28. As can be appreciated, if the pressure in the flow line between, for example, the output of the pump 22a and the wheel or brake cylinder such as 12a reduces below the pressure needed to maintain the isolation valve in its switched state, the isolation valve such as 42a will switch to the condition shown in FIGURE 1 thereby communicating the master cylinder to the hydraulic wheel. Such a condition is not desirable during an anti-skid maneuver and, as such, the ECU 30 will monitor the pressure in the hydraulic cylinder to maintain same above the pressure needed to maintain the isolation valve 42a in its switched state. Typically, this pressure is in the vicinity of approximately 30 psi (206.8 K.Pascal).

20

The operation of the system with regard to a skidding rear wheel is essentially identical to that described with regard to skidding front wheels with the exception that the reduction in motor speed and the opening and closing of valve 58 (if same is a continuously variable valve) will simultaneously reduce the hydraulic pressure in both of the rear hydraulic cylinders even though only one of the rear wheels is skidding.

30

In addition, as can be seen from the discussion below, the configuration of the braking system 10 shown in FIGURE 1 also provides the vehicle with front wheel

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traction control as described below. The goal of a wheel traction control system is to maintain the rotational speeds of both axle wheels generally at the same value. Slight differences in wheel speed are permitted as the
5 opposing axle wheels will rotate at different speeds during a turn maneuver. Consider the operation of a front wheel drive vehicle having the braking system 10. If one of the wheels, such as 14a, is on ice then in response to the depression of the accelerator pedal 59
10 this wheel will tend to accelerate dramatically while the other wheel, such as 14b which may be on dry pavement, will accelerate in proportion to the higher forces generated between the tire/road interface. The ECU will monitor the wheel velocities by interrogating the wheel
15 speed sensors 60a,b. If the difference in these velocities is greater than a preset amount the ECU will generate a motor control signal such as M1 to increase the pressure supplied to the brake cylinder 12a thereby reducing the rotational speed of the higher rotating
20 wheel 14a to a level substantially equal to that of the slower rotating wheel 14b. The speed of the motor 24a and output pressure generated by pump 22a are modulated to control the speed of the faster rotating wheel. It should be appreciated that during the traction control
25 mode of operation hydraulic pressure is not generated within the master cylinder 38 since the vehicle operator's foot is on the accelerator pedal 59.

Reference is made to FIGURE 7 which illustrates an
30 alternative valve 26' which can be substituted for any of the valves 26a,b or 58 discussed above. The output of any of the pumps is connected to a flow regulator valve generally shown as 26'. The valve 26' has an inlet port

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64 connected to a pump such as 22a, an outlet port 66 is connected to a particular brake cylinder such 12a, and a bypass or exhaust port 68 connected to the sump 28. The valve 26' includes a first flow passage 70 which
5 incorporates a bypass control flow orifice 72. This orifice is sized to produce a pressure drop of about 10% of maximum pump pressure (typically about 100 psi). The bypass or exhaust port 68 may optionally include an outlet orifice 69. This outlet orifice is typically
10 sized to produce the highest exhaust flow desired to release the brakes. The valve 26' includes a bypass passage 74 in parallel between the inlet and outlet ports respectively. Situated in the bypass passage is a slidable valve element 76 to selectively open and close
15 the bypass port 58. A spring 77 biases the valve element 74 in a direction to open the exhaust port 58. As shown the spring 75 biases the valve element 74 to open communication between the exhaust port 68 and the output port 66. During the fill mode of the operation, that is
20 when the pump is pressurizing a brake cylinder 12a, the bypass control flow orifice 72 generates a pressure differential across the bypass passage 74. This pressure differential acts on the valve element 76. In the steady state an equilibrium condition is achieved where the
25 pressure forces balance the spring force and the pressure in the brake cylinder 56 remains constant. As can be seen, the valve element 74, in response to an increasing pump flow rate, moves against the spring 75 to partially or fully close the exhaust port in proportion to the
30 pressure differential generated across the bypass control flow orifice 72. At high flow rates the valve element 74 completely closes the exhaust port 68 so that all of the pump flow is available to rapidly pressurize the brake

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cylinder 12a. The pressure force across the bypass control flow orifice 72 is proportional to the square of the flow rate of fluid. A reduced pump flow causes a reduction in the pressure differential and permits the
5 valve element 74 to move to partially or fully open the exhaust port 68, facilitating rapid pressure reduction at the wheel cylinder through passage 74a.

Reference is made to FIGURE 2 which illustrates an
10 alternative embodiment of the present invention. Like components are shown with similar numerals. As can be seen, the structure of the system 80 shown in FIGURE 2 is substantially identical to the system illustrated in FIGURE 1. As can be appreciated, the system 80 in
15 addition to providing normal electrohydraulic service brake operation, also provides for four channel antilock and four channel traction control. The basic difference in system 80 as compared with system 10 relates to the second electrohydraulic actuator generally shown as 52'
20 wherein two pumps 52a and 52b, two motors 56a and 56b and two valves 58a and 58b are utilized.

The operation of system 80 during normal service braking, antilock and traction modes of operation is
25 substantially the same as that described for system 10. The inclusion of the additional pump 54b, motor 56b and valve 58b in the rear electrohydraulic actuator 52' provides for independent antilock control and traction control of the individual rear wheel.

30

Reference is made to FIGURE 3 which further illustrates a further alternate embodiment of the present invention. As will be seen the major features of the

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system 100 is a four wheel push through capability from the master cylinder 38, a single motor 24 driving the tandem combination of pumps 22a and 22b, a diagonal brake split with mechanical proportioning valves. This system

5 100 also provides for a simplified two channel, antilock system. In system 100 the first electrohydraulic actuator 20' is substantially identical to the electrohydraulic actuator 20 shown in FIGURE 1. The major exception is the elimination of one of the motors

10 such as 24b yielding a more economical system. As shown in FIGURE 3, a single motor 24 having extending ends of the motor shaft is coupled to the tandem combination of the individual pumps 22a and 22b. The isolation valves 42a and 42b are also incorporated within this system 100

15 and function in the manner described above. Positioned between each isolation valve 42a and 42b and its respective brake cylinder 12a, 12b is an electrically operable build/decay valve 102a and 102b respectively. During antilock operation of the front brakes, the

20 build/decay valves 102a and 102b, in response to control signals generated by the ECU 30, are switched to their other state wherein communication between the various isolation valves 42a,b and the brake cylinders 12a,b is terminated and the brake cylinders 12a,b are communicated

25 to the sump 28 to permit the rapid decay of brake pressure. The build/decay valves 102a,b, under the control of the ECU 30, are selectively activated and deactivated to cause the periodic build and or decay of hydraulic pressure within the cylinders 12a,b during

30 antilock braking operation in a known manner.

The rear brake actuator generally shown as 50, comprises a conventional rear hydraulic brake arrangement

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utilizing mechanical proportioning valves 104a and 104b of known variety which are communicated to the rear hydraulic cylinders 16a and 16b. The brake system 100 utilizes a diagonal split wherein the right proportioning valve 104b is communicated to the front left brake cylinder 12a and wherein the left proportioning valve 104a is communicated to the right brake cylinder 12b. If the ECU determines that either of the front wheels 14a or 14b (or both rear wheels) are skidding or are in an impending skid condition, the pump speed is varied and/or the various build/decay valves 102a,b will be selectively activated and deactivated. As can be appreciated, the activation and deactivation of these build/decay valve 102a,b will also correspondingly build and decay the pressure within the rear hydraulic cylinders 16a and 16b.

Reference is made to FIGURE 4 which illustrates a dual circuit electrohydraulic system 120. The front electrohydraulic actuator generally shown as 122 comprises a single pump 22, motor 24 and valve 26. In addition, the actuator 122 includes a first check valve 124. The output of the pump 22 through the check valve 124 is communicated to electrically controlled build/decay valves such as 102a and 102b. These valves are configured such that during normal service brake operation the output of the pump 22 is directly communicated to the isolation valves 42a and 42b. During antilock operation the build/decay valves 102a,b communicate the corresponding front hydraulic cylinders 12a and 12b to the sump 28 through a flow passage 126 which essentially parallels the pump 22 and check valve 124.

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The various chambers 38a and 38b of the master cylinder are as before communicated to the isolation valves 42a and 42b and thereafter to the wheel or brake cylinders 12a and 12b. Various pressure sensors 40a, 40b
5 and 57 are provided to generate pressure signals indicative of the pressures generated in the master cylinder or the pressure generated by the operation of the pump 22.

10 The rear or second hydraulic actuator is generally shown as 130. The construction is essentially similar to that illustrated in the earlier figures with the exception of the inclusion of a second check valve 132 to prevent the reverse flow of fluid into the pump 54. The
15 output of the check valve 132 is communicated to the rear hydraulic cylinders 16a and 16b through an additional set of build/decay valves 134a and 134b.

During normal service brake operation, various
20 build/decay valves 102 and 134 are in the conditions as illustrated. The isolation valve 42 will have changed state communicating the pump 24 to the various front hydraulic cylinders 12a,b. If the ECU 30 determines that any of the front wheels 14a,b is in a skid or impending
25 skid condition the ECU will initially reduce motor speed to reduce pump pressure and hydraulic cylinder pressure to permit the wheel to freely roll if additional pressure reduction is required the ECU 30 will generate a control signal to the appropriate build/decay valve such as 102a
30 or 102b causing same to change state thereby communicating the hydraulic cylinder of the skidding wheel to the sump 28 through passage 126 thereby causing a rapid decay in its pressure. Thereafter the

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build/decay valve is alternatively switched to control the building and subsequent decaying of the hydraulic pressure in the skidding wheel in the manner as known in the art. If the ECU determines that either of the rear
5 wheels 18a,b is in a skid or a impending skid condition the motor 56 speed is reduced and/or the appropriate build/decay valve 134a or 134b is caused to change state thereby communicating the corresponding hydraulic cylinder to the sump 28 through passage 126.

10

The operation of the system during four wheel traction control is as follows. During traction control and since system 120 utilizes a single pump 22 and motor 24 for the front brakes, it is not possible to regulate
15 the output of the pump to control the speed of a single highly rotating wheel as described with regard to the traction control system available with the system 10 shown in FIGURE 1. However, the system 120 does include the individual build/decay valves 102a and 102b. If for
20 example wheel 14a rotates at a speed substantially greater than the speed of wheel 14b, the ECU will energize the motor 24 causing pump 22 to operate. In addition, the ECU 30 will generate a control signal to energize the build/decay valve 102b of the slower
25 rotating wheel preventing a build-up of pressure within its corresponding hydraulic cylinder 12b. By maintaining the build/decay valve 102a in the state illustrated in FIGURE 4, the output of the pump is communicated to the wheel or brake cylinder 12a causing a reduction in its
30 velocity.

Reference is made to FIGURE 5 which shows a further alternative embodiment of the present invention. The

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major features of this alternative embodiment are that the push through master cylinder capability is only utilized with the front wheels, and a single motor/pump combination is utilized. In addition the system 150 provides for what is known as a three channel antilock capability wherein each of the front wheels is controlled independently (first and second channel) and each of the rear brakes are controlled in tandem (third channel). The system 100 also provides for front wheel traction control. As can be seen the basic construction of the front electrohydraulic actuator 20 is substantially identical to that shown in FIGURE 1, however, the actuator 120 utilizes a single pump 22, motor 24 and valve 26. The output of the pump 22 is communicated to both isolation valves 42a,b which master cylinder pressure. The output of each isolation valve 42a,b is connected to its corresponding front brake cylinder 12a,b through an electric build/decay valve 102a,b. The rear hydraulic actuator comprises a single mechanical proportioning valve 104 which receives pressurized fluid directly from the output of the pump 22 through a single build/decay valve 134.

Reference is made to FIGURE 8 which illustrates a block diagram of a typical control circuit 200 for controlling any of the motors 22 and 56. One such circuit would be used for each motor used. Even though this FIGURE 8 illustrates the use of various discrete electrical components it is contemplated that part of the circuit will be embodied in the ECU 30. The circuit 200 includes a comparator 202 which compares a command signal, P_c , such as commanded pressure to the actual pressure, P_a , in a particular brake cylinder or brake

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line to generate an error signal P_e . Commanded pressure can be obtained directly from a pressure sensor which measures master cylinder pressure such as 40a or 40b. Alternatively, the output of the force transducer 36 with
5 appropriate scaling can be used as a measure of the commanded signal. As shown, actual brake cylinder pressure is derived from the output of an appropriate pressure sensor such as 57a. The pressure error signal is input to a pressure controller 204 which may include
10 a proportional-integral-differential controller. The output of the pressure controller is input to a pulse-width modulating circuit 206 of known variety. Motor current limiting circuitry 208, of known design may be used to protect the motor 24. In operation the
15 speed of the motor and pump being controlled by the circuit will be controlled to drive the error signal P_e to zero during pressure build intervals. During intervals when the operator reduces brake pedal effort, the pressure command signal P_c will correspondingly be
20 reduced. In the context of the control circuit 200, it can be seen that the error signal P_e will become negative. This negative going error signal will be used to essentially drive the respective motor command signal M to zero, thereby permitting the pressure within the
25 service brake cylinders to reduce through the appropriate valve such as 26a, 26b or 58. During intervals when an antilock or adaptive traction system is operative the command signal will be driven by the control algorithm.

30 As mentioned above, the valves 26a, 26b and 58 may be a linear or proportional solenoid or a fixed orifice. During pressure decay periods, the brake cylinder pressure will decay through such valves as well as

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through any internal pump leak paths. As can be appreciated, if a fixed orifice valve is used the decay period of the brake cylinder pressure is limited by the size of the fixed orifice. If however, a variable
5 orifice valve is used the ECU 30 can vary the size of the effective orifice of this type of valve to control the decay rate of the brake pressure. This type of control can be accomplished by generating a valve command signal in the ECU 30. This valve command signal is received by
10 a pulse width modulator (not shown) and communicated to the valve to control its effective orifice size.

The control circuit 200 of FIGURE 8 is more aptly suited for the control of motors and pumps associated
15 with the front wheels of a vehicle. A control circuit for controlling the motors and pumps of the rear wheels of the vehicle is essentially the same of that shown in FIGURE 8 with the exception that the command signal input to the comparator 202, for the rear wheels, may
20 include a scaling function (not shown) to generate a rear wheel command signal by scaling the front wheel command signal P_c , to account for any desired front-to-rear brake proportioning.

25 As mentioned above, the present invention includes means for driving the motor(s) in anticipation of operator applied brake activity to improve the response of the system. This means includes generating a low level motor command M_a , in response to changes in:
30 accelerator pedal force, throttle position, low output levels of the brake pedal force sensor or pressure sensor(s) or activation of a brake light switch. The control circuit 200 also includes an additional

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comparator 210, forward of the controller 204. The low level motor command signal M_a is input to this comparator 210. In response to this signal the motor (and pump), being controlled, is caused to slowly rotate at a rate which will not cause any of the isolation valves 42 to change state. As can be seen from FIGURE 8 the circuit operates in an open loop control mode of operation when the low level motor command signal M_a , is applied. During this operation the ECU 30 monitors the output of the various brake line pressure sensors 57 a,b,c to insure that the motor command signal is below that needed to activate any of the isolation valve or brake cylinders 12, 16 but still sufficiently high to cause the motor and pump to rotate to overcome the effects of inertia/friction. The switches which are diagrammatically shown is FIGURE 8 are to show that the pressure signal P_e is not developed during the time the low level signal M_a is driving the motor. At such time that the brake pedal is sufficiently applied, the motor is controlled in a closed loop manner as described above and the signal M_a is not generated.

FIGURE 8 also shows an additional signal P_i entering the comparator 202. One of the advantages of electrohydraulic brake activation achieved by the present invention is that the activation of any of the brakes can be accomplished by a brake intervention signal P_i , independent of operator activity. In the context of the present invention, the intervention signal would be generated external to the circuit 200 shown in FIGURE 8. Such an intervention signal could be generated by a distance or range sensing system when the vehicle is approaching another object too closely. As an example

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such an external system, that is, external to circuit 200, may be a radar or other position-determining system carried by the vehicle or embedded in the roadway or adjacent to the roadway. In response to such an intervention signal, the onboard ECU 30 would control the vehicle throttle as well as generate a brake activation signal to decelerate the vehicle, or stop the vehicle in the case of an emergency, or apply the brakes to maintain adequate vehicle-to-vehicle spacing. In an alternate configuration, the intervention signal could be used to assist the driver during a parking maneuver to automatically apply the brakes to avoid an accident.

Many changes and modifications in the above described embodiment of the invention can, of course, be carried out without departing from the scope thereof. Accordingly, that scope is intended to be limited only by the scope of the appended claims.

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IN THE CLAIMS

1. A braking system for front and rear service brakes of a vehicle comprising:

5 first electrohydraulic means, comprising an electrohydraulic actuator for providing the primary source of pressurized fluid for the front service brake in response to a first control signal representative of operator applied braking effort during normal front
10 service braking operation;

master cylinder means for pressurizing brake cylinders associated with the front service brakes in response to operator applied braking effort and for providing a secondary means to actuate the service brakes
15 in the event the first electrohydraulic means does not operate;

isolation valve means, located upstream of each front brake cylinder for selectively communicating fluid pressurized from the master cylinder or fluid pressurized
20 by the first electrohydraulic means to a particular one of such cylinders; and

hydraulic means for pressurizing the rear service brakes and

first means for generating control signals to
25 activate various system components.

2. The system as defined in Claim 1 wherein the hydraulic means includes second electrohydraulic means, comprising another electrohydraulic actuator for
30 providing the only source of pressurized fluid for the rear service brakes in response to an electric second control signal.

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3. The system as defined in Claim 1 wherein the isolation valve means comprises, for each front service brake, a pressure responsive isolation valve responsive to the pressure developed by the first electrohydraulic means for selectively communicating the first electrohydraulic means or master cylinder to a particular front hydraulic cylinder.

4. The system as defined in Claim 1 wherein the isolation valve means is responsive to the pressure developed by the master cylinder means and the first electrohydraulic means.

5. The system as defined in Claim 1 wherein the isolation valve means comprises for each front service brake an electrically responsive isolation valve.

6. The system as defined in Claim 5 including build/decay valve means, responsive to a control signal, including a build/decay valve communicated with each isolation valve means and its corresponding brake cylinder for permitting pressure to build and decay therein depending on the state of the valve.

7. The system as defined in Claim 1 where in the first electrohydraulic means includes at least one pump driven by a motor in response to a motor control signal, to permit the pump to pressurize at least one front brake cylinder to a level corresponding to the operator applied braking effort.

8. The system as defined in Claim 7 wherein the first hydraulic means includes a pump and a motor for each

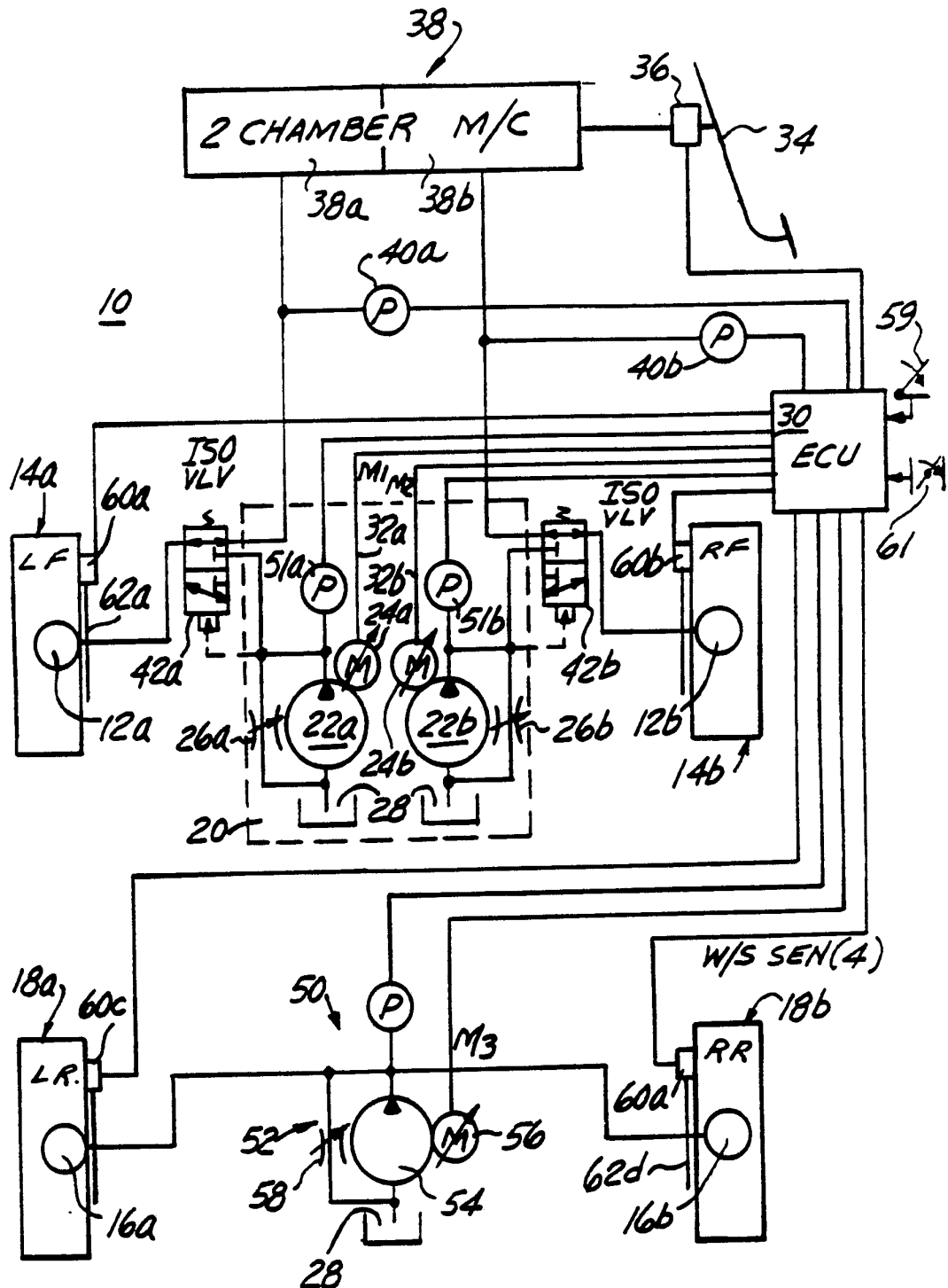
-25-

front brake cylinder, each motor responsive to a separate motor control signal.

9. The system as defined in Claim 1 wherein the first
5 hydraulic means includes a single motor, responsive to a motor control signal and a pair of pumps driven by the single motor for pressurizing left and right side front hydraulic cylinders.
- 10 10. The system as defined in Claim 6 wherein the hydraulic means for pressurizing the rear service brakes, includes first proportioning valve means for scaling the pressure applied to a right rear service brake in proportion to the pressure applied to a left front
15 service brake and second proportioning means for scaling the pressure applied to a left rear service brake in proportion to the pressure applied to a front right service brake.

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FIG. 1



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FIG. 2

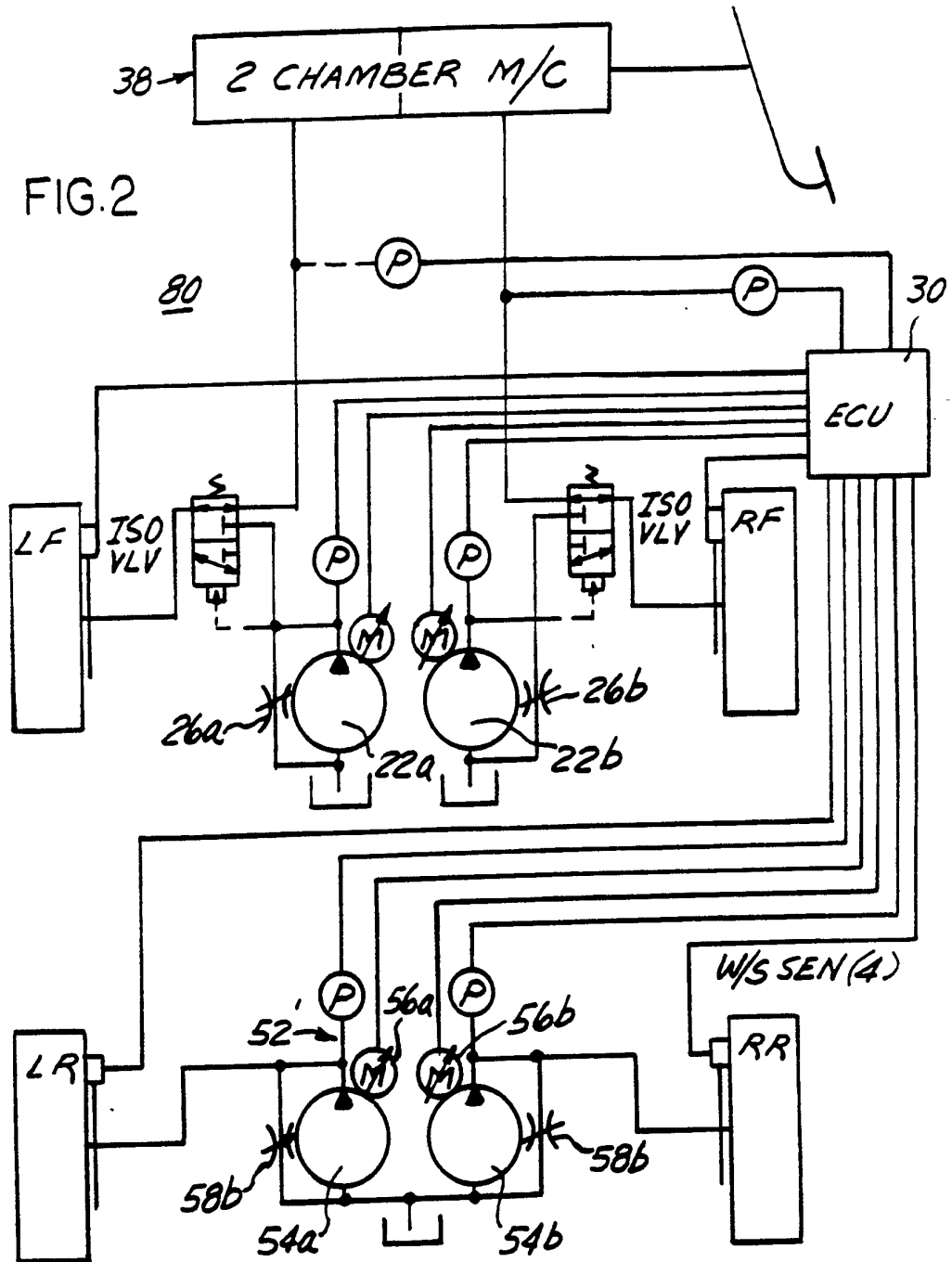


FIG. 6

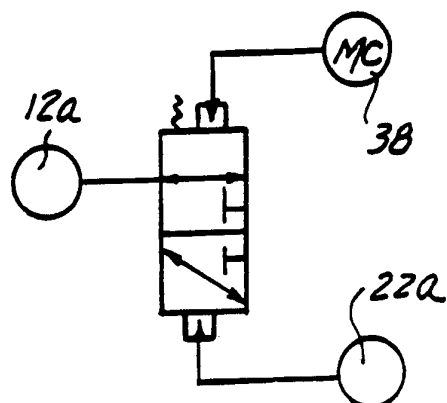


FIG.3

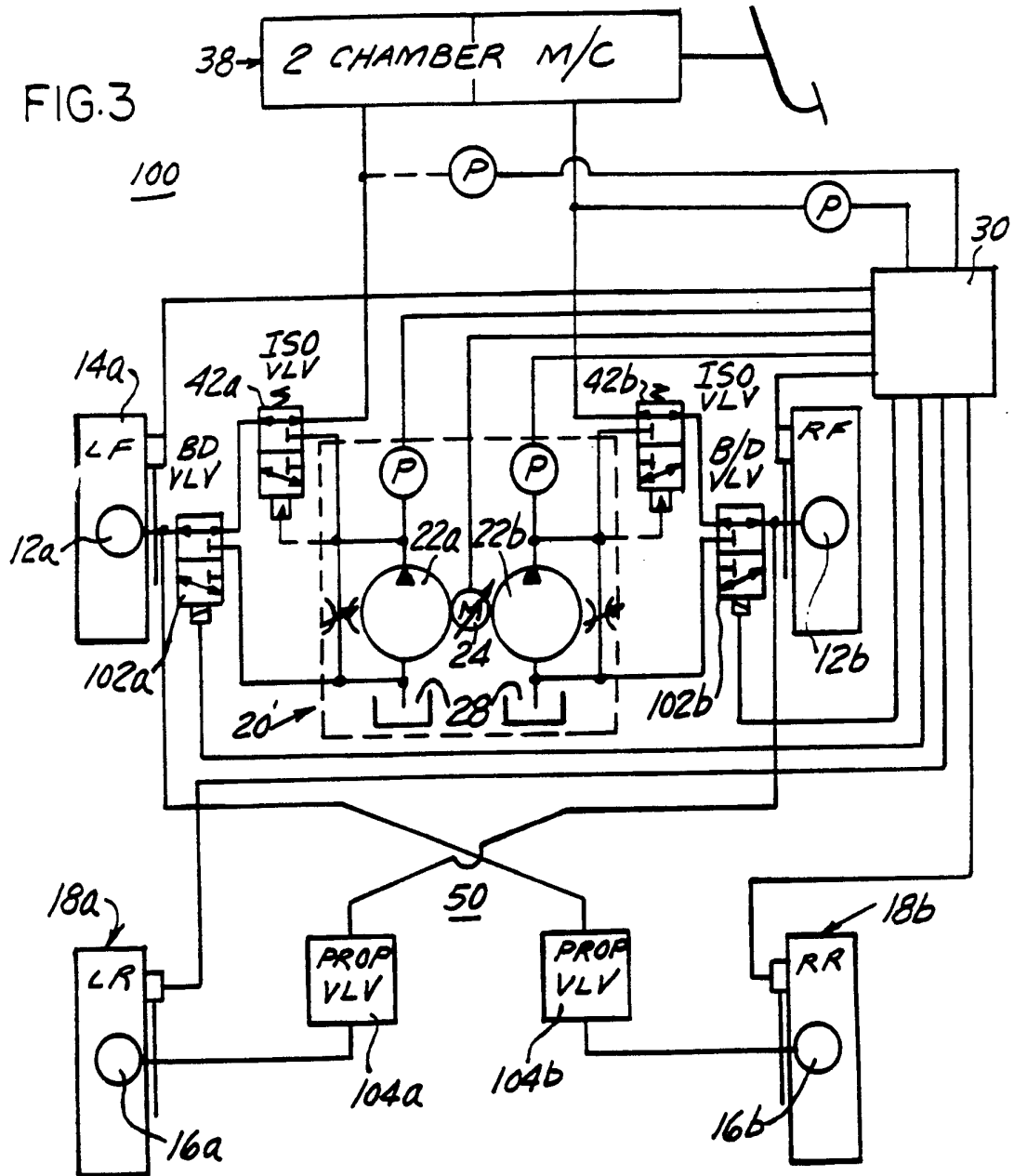
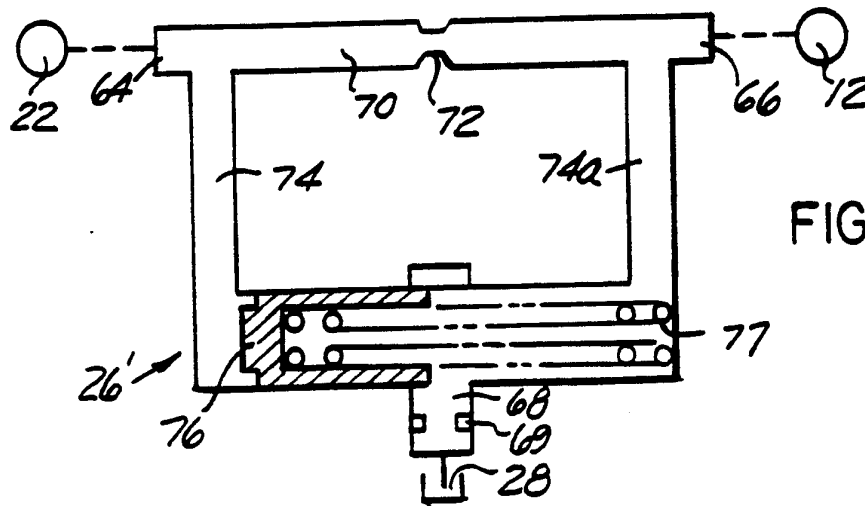
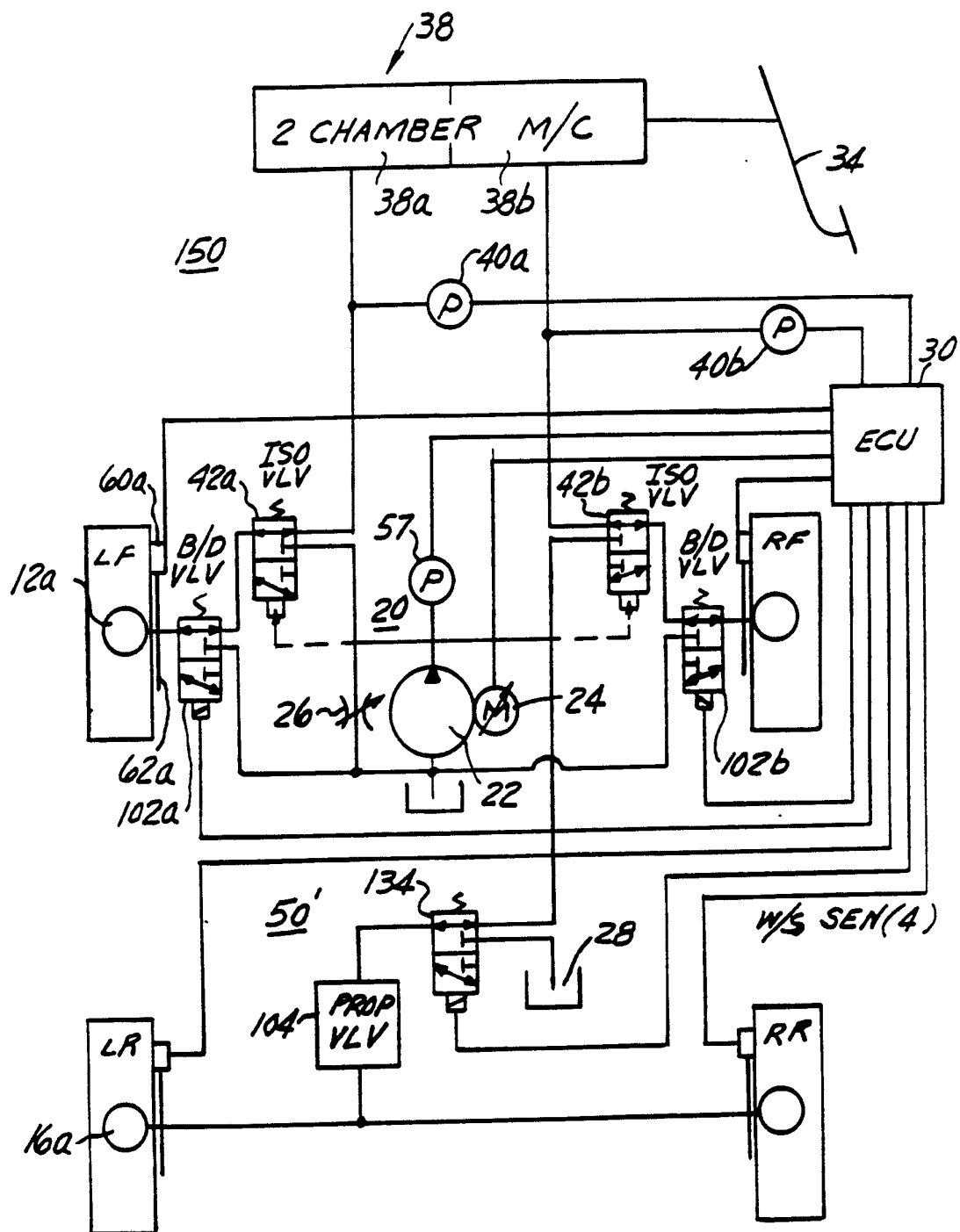


FIG. 7



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FIG. 5



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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 92/04806

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁴		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ : B 60 T 7/00, B 60 T 13/74		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁵	B 60 T	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	US, A, 4 382 364 (THOMAS) 10 May 1983 (10.05.83), see abstract. --	1
A	DE, A1, 3 626 751 (BOSCH) 24 September 1987 (24.09.87), see fig. 1,2; abstract. --	1
P	US, A, 5 031 968 (TAKATA) 16 July 1991 (16.07.91), see abstract. ----	1
<p>¹⁰ Special categories of cited documents: ¹⁴</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>"Z" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
02 October 1992	19 OCT 1992	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	PANGRATZ e.h.	

ANHANG

zum internationalen Recherchen-
bericht über die internationale
Patentanmeldung Nr.

ANNEX

to the International Search
Report to the International Patent
Application No.

ANNEXE

au rapport de recherche inter-
national relatif à la demande de brevet
international n°

PCT/US/92/04806 SAE 62194

In diesem Anhang sind die Mitglieder
der Patentfamilien der im obenge-
nannten internationalen Recherchenbericht
angeführten Patentdokumente angegeben.
Diese Angaben dienen nur zur Unter-
richtung und erfolgen ohne Gewähr.

This Annex lists the patent family
members relating to the patent documents
cited in the above-mentioned inter-
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Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
US A 4382364	10-05-83	AU A1 43634/79 AU B2 519733 BR A 7900577 DE A1 2903708 FR A1 2416147 FR B1 2416147 GB A1 2013297 GB B2 2013297 IT A0 7919780 IT A 1109890 JP A2 54120373 JP B4 61014980	09-08-79 17-12-81 28-08-79 02-08-79 31-08-79 30-09-83 08-08-79 03-03-82 01-02-79 23-12-85 18-09-79 22-04-86
DE A1 3626751	24-09-87	keine - none - rien	
US A 5031968	16-07-91	EP A1 389993 JP A2 2299962	03-10-90 12-12-90