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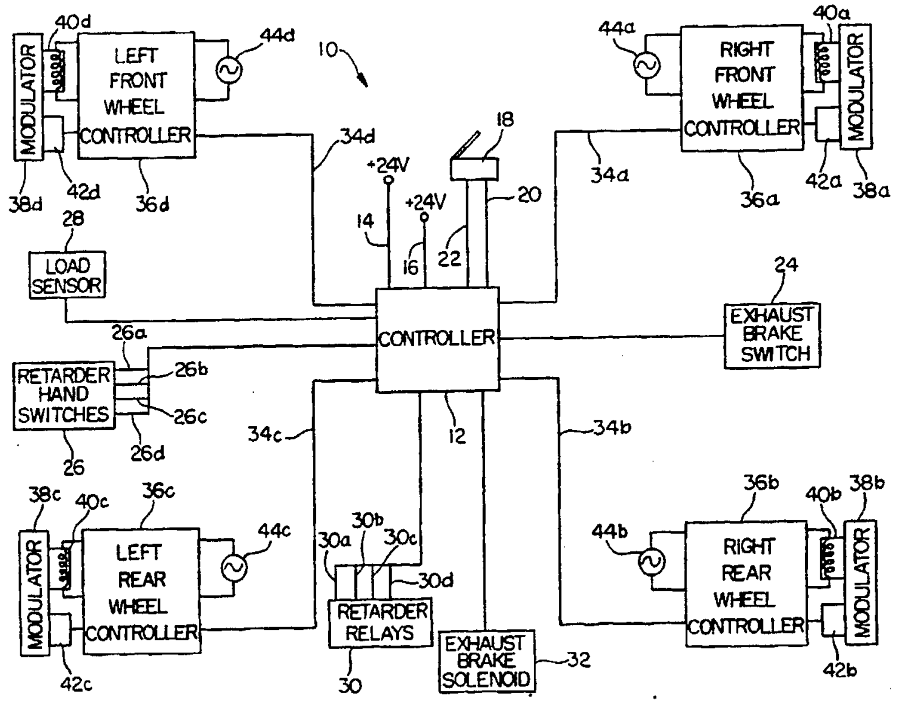

(57) Abstract

A fluid pressure braking system for a vehicle equipped with a drive line retarder automatically reduces the braking pressure level communicated to the brakes controlling the driven wheels of the vehicle to adjust for the retardation effected by the retarder. The retarder is actuated automatically each time the brake is applied by calculating the appropriate retardation level as a function of the brake pressure being demanded by the vehicle operator and by the load carried by the vehicle.

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ELECTROPNEUMATIC BRAKE CONTROL WITH RETARDER APPORTIONING

This invention relates to an integrated braking system for a heavy duty vehicle equipped with both an electropneumatic braking system and a retarder.

Many heavy duty vehicles are equipped with both a pneumatic braking system and an operator controlled vehicle retarder that applies a retarding torque to the vehicle driveline. On existing vehicles, the retarder is used to retard the vehicle on long downhill grades and is rarely used otherwise. Retarders are generally not used when the normal pneumatic braking system is used, because braking on the driven wheels is never balanced with the braking on the front wheels if the retarder is used during operation of the pneumatic braking system, and because the operator must operate a hand control, requiring that the operator remove a hand from the steering wheel.

Integration of the retarder control system with the control system for the pneumatically actuated brakes according to the present invention distributes the braking level required by the vehicle operation between the systems without jeopardizing braking balance front-to-rear of the vehicle. Although retarders in use today are controlled by switches operated by the vehicle operator, the retarder is activated automatically when the brake treadle is operated according to the present invention. Accordingly, the retarder is actuated every time the electropneumatic braking system is actuated (unless the vehicle speed drops below a predetermined threshold, or until intervention of the adaptive braking system is initiated) resulting in considerable savings in brake lining wear, while maintaining the requested braking level and balance.

The present invention is useful with all types of retarders in common use today. Staged retarders usually provide four discrete stages or levels of retardation which are under the control of the vehicle operator by operating switches controlling the retarders. A variable retarder is similar to a stage retarder, but is continuously variable over a predetermined range rather than being actuatable in discrete stages. Engine brakes and exhaust brakes also provide vehicle retardation.

These and other advantages of the present invention will become apparent from the following description, with reference to the accompanying drawings, in which:

Figure 1 is an overall system schematic of an electropneumatic braking system with an integrated retarder control made pursuant to the teachings of the present invention;

Figures 2, 3, 5a, 5b and 6-8 are schematic logic diagrams illustrating the manner in which the system according to the present invention controls braking pressure and actuation of the drive line retarders; and

Figure 4 is graphical representation of the relationship between the retarder stage and the equivalent braking pressure.

Referring now to the drawings, an electropneumatic braking system with integrated retarder control generally indicated by the numeral 10 includes a central or master controller 12 which, for redundancy, preferably receives power from each of two 24 volt sources 14 and 16 if the vehicle is equipped with a 24 volt system, or from 12 volt sources if equipped with a 12 volt system. A brake treadle signal generator generally indicated by the numeral 18 is mounted in the operator's compartment of the vehicle and is actuated by the vehicle operator to effect braking. Preferably, the signal generator 18, for redundancy, simultaneously generates two independent signals, which are transmitted over independent lines 20, 22 to the controller 12. Each of the signals vary in accordance with the distance the driver has depressed the brake treadle.

The central or master controller 12 also receives an input signal from an engine or exhaust brake switch (or both) 24, which is actuated when the operator wishes to actuate the vehicle engine and/or, exhaust brake. Controller 12 also receives input signals from the retarder hand switches 26. If a four-stage retarder is used, four separate switches 26a, 26b, 26c and 26d are actuated to activate each of the increasingly retarding stages of the retarder. The retarder hand switches 26 are mounted in the vehicle operator's compartment for operation by the vehicle operator. Controller 12 further receives a signal from vehicle load sensor 28, which generates a signal which varies in accordance with the load carried by the vehicle. For example, the load sensor 28 may be a pressure sensor which generates a signal which varies in accordance with the pressure in the vehicle airbag suspension if the vehicle is equipped with an air suspension system, or the load sensor 28 may generate a signal which varies in accordance with the deflection of the vehicle suspension system caused by increasing vehicle load. In either case, the load sensor 28 is conventional.

The controller 12 also generates output signals which are transmitted to the retarder relays generally indicated by the numeral 30. If a four stage retarder is used, four separate connections 30a, 30b, 30c and 30d are connected to four separate relay actuators which actuate the four increasingly retarding stages of the retarder. Controller 12 also generates an output signal which may be transmitted to an exhaust brake actuating solenoid 32, which actuates the exhaust brake. In addition to, or instead of, an exhaust brake solenoid, an engine brake, which is also solenoid actuated, may be used.

The controller 12 is also connected by data transmission lines 34a, 34b, 34c and 34d to a right front wheel controller 36a, a right rear wheel controller 36b, a left rear wheel controller 36c, and a left front wheel controller 36d. Each of the controllers 36a-d includes a brake pressure modulator 38a, 38b, 38c and 38d, each of which includes a coil 40a, 40b, 40c and 40d which is actuated by the corresponding controller in accordance with signals transmitted from the master controller 12. Each of the controllers 36a-d includes a brake pressure sensor 42a, 42b, 42c and 42d, which measures the braking pressure. The sensors 42a-d transmit a signal representing the braking pressure to the left front wheel controller, which in turn transmits this information to the master controller 12 through the data transmission lines 34a-d. Each of the controller 36a-d further includes wheel speed sensors 44a, 44b, 44c and 44d, each of which generates a signal representing the wheel speed of the wheel controlled by the corresponding controller 36a-d. This wheel speed signal is transmitted to the controller 12 through the data transmission lines 34a-d.

In the following discussion, it will be assumed that the front wheels of the vehicle are the non-driven wheels, and that the rear wheels are the driven wheels. Since the retarders and/or exhaust and engine brake apply a retarding torque to the drive train, only the rear wheel is affected by the retarder. According to the present invention, one or more stages of the retarder is switched on every time that a brake application is effected that requests a braking level at least equal to that provided by the lowest retarder stage (assuming that the vehicle is traveling above a predetermined minimum speed and that an incipient skidding condition does not exist). The pressure level transmitted to the rear wheel brakes is adjusted for the effects of the retarders so that braking balance front to rear is maintained. The extent of braking is controlled by the vehicle operator through operation of the treadle 18. When the treadle 18 is depressed, a signal requesting a predetermined brake pressure level is sent directly to the front wheel controls 36a and 36d. Pressure level in the brakes controlling the front wheels is then established in the manner set forth in co-pending U.S. patent application Serial No. 7/894,386. The braking pressure requested in the rear wheel brakes, however, is adjusted depending upon the retardation level that has been set, either by the hand switches 26, or automatically as will hereinafter be described upon actuation of the brake treadle 18. Any additional braking required to achieve a balance front to rear is generated by communicating an appropriate pneumatic pressure level to the rear wheel brake actuators. This is done by transmitting an electronic brake pressure request signal through the data transmission lines 34b, 34c to the rear wheel controllers 36b and 36c. The pressure in the rear wheel brakes is then established as set forth in the aforementioned U.S. patent application 7/849,386.

Referring now to Figure 2, the following routine for brake control generally indicated by the numeral 46 is illustrated. The routine first calculates that brake chamber pressure requested by the vehicle operator, as indicated at 48. This is preferably done by merely scaling the inputs received from the brake treadle signal generator and then choosing one of the two inputs (generally the higher input). As discussed above, the controller 12 includes an algorithm for antiskid control. Accordingly, as indicated at 50, if the pressure requested by the vehicle operator is so high that one of the wheels is about to lock up, the adaptive braking subroutine is called to calculate a brake pressure which will effect a brake application just below lock up pressure. Since the adaptive braking system forms no part of the present invention, and any one of a number of such routines may be used, the routine will not be illustrated in detail. The retardation level is then calculated, as illustrated at 52. This is done according to the subroutine illustrated in Figures 5a and 5b hereof, which will be described in detail hereinafter. The program then calculates the retarder apportioning to determine the brake pressures that should be sent to the brakes controlling each of the wheels of the driven axle, as indicated at 54 in Figure 2. This subroutine will be explained in detail hereinafter with reference to Figure 3. The program then, as indicated at 56, sends the desired brake pressure as determined by the subroutine calculating the retarder apportioning as indicated at 54 to the controllers 36b and 36c controlling the driven wheels of the vehicle. It will be remembered that the braking pressure controlling the wheels on the non-driven axle (controllers 36a and 36d) are the scaled braking pressure, as modified by the adaptive braking routine if necessary. The calculated retarder level is then used to set the retardation level, as indicated at 58. As will be explained hereinafter, the vehicle operator is allowed to override the retardation level set by the program by controlling the hand switches

26a-d to thereby manually set the retardation level. The brake control then ends and returns as indicated at 60.

Referring now to Figure 3, the subroutine called at 54 in Figure 2 to calculate the retarder apportioning to determine the brake pressure that is to be sent to the brake chambers of the brakes controlling the driven wheels will now be described in detail. Referring to Figure 3, the retarder apportioning subroutine indicated at 62 is called at 54 in the program illustrated in Figure 2. As indicated at 64, the brake pressure requested by the vehicle operator is tested to determine if a brake pressure higher than zero is being requested. If a zero brake pressure is being requested, the program immediately returns a zero brake pressure to the calling routine, as indicated at 66. If a braking pressure higher than a zero braking pressure is being requested, the program then determines if there are four retarder stages on, as indicated at 66. The number of retarder stages turned on is determined as will hereinafter be described with respect to Figures 5-7. If there are four retarder stages on, the braking pressure request is set equal to that requested by the vehicle operator by operation of the treadle 18 <u>minus</u> a four stage retarder adjustment, as indicated at 68 in Figure 3. The retarder stage adjustment is determined empirically and is plotted graphically as illustrated in Figure 4. The adjustment for each retarder stage is determined by measuring vehicle deceleration on a flat surface with a uniform coefficient friction. This data is collected and plotted in graphical form as illustrated in Figure 4. The data can be used in the program controlling braking by storing the data for each retarder stage in memory.

The difference between the brake pressure requested by the vehicle and the four stage adjustment as calculated at 68 is then further adjusted, as indicated at 70, for the effect of the engine and/or exhaust brake. According to the present invention, the engine and/or exhaust brake can only be set manually, but it is possible to set the engine brake automatically by the same manner as the retarder stages are set automatically as will be discussed hereinafter. If the engine brake is on, the engine brake adjustment, which is determined the same way of the retarder stage adjustment, is subtracted from the brake pressure request, as indicated at 72. The result is then tested, as indicated at 74, to determine if this braking pressure is greater than zero. If the engine brake is off, the results of the adjustment for the retarder effect is sent directly to decision block 74. If the brake pressure is less than zero, the pressure is set equal to zero, as indicated at 76, then a return to the calling routine is indicated at 66. If pressure is greater than zero, the pressure is sent directly to the calling routine. It is possible for the requested calculated brake pressure, after adjusting for retardation, to be less than zero, either because of the fact that the retardation level has been sent manually, or because of the fact, as will hereinafter be described, the setting of the retardation level automatically takes factors, such as vehicle load, into account other than the brake pressure being requested by the vehicle operator.

If there are three, two, or one retarder stages on, as tested for at 78, 80 and 82, the corresponding adjustment for the third stage, second stage, or first stage retardation is made, as indicated at 84, 86 and 88 in Figure 3. In any case, after this pressure is calculated at 68, 84, 86 or 88 is adjusted for the effect of the engine brake, the requested brake pressure is then sent back to the calling routine, where it is set to the corresponding brake chambers, as indicated at 56 in Figure 2. The controllers 36b and 36c then effect a brake application in accordance with the pressure level requested.

The manner in which the retardation level is set automatically when a vehicle operator effects a brake pressure request by operating the treadle 18 will now be described in detail with reference to Figures 5a and 5b. The retarder control subroutine is started as indicated at 78, and then proceeds to determine whether or not the vehicle velocity reference is less than a predetermined minimum retarder vehicle speed, as indicated at 80. Vehicle velocity reference may be determined, for example, by averaging the speed set by the speed sensors 48a and 44d of the non-driven wheels of the vehicle. The minimum retarder speed is a relatively low speed set arbitrarily at a speed at which it is desirable that the retarders not operate, since retarders are not efficient at low vehicle speeds. If the vehicle velocity reference is less than the retarder vehicle speed reference, the retarder level is set at a zero retarder level, as indicated at 82. The program then returns this retarder level of zero to the calling routine. If the vehicle reference is above the minimum vehicle speed reference, the program then tests, as indicated at 84, as to whether the load being sensed by the load sensor 28 is less than a predetermined minimum load count. The load sensor 28 generates a load count that increases and decreases as the load carried by the vehicle is increased or decreased, after a predetermined offset. If the load sensor output is less than the minimum load count, the variable load sensor is set equal to the minimum load count, as indicated at 86. The program then proceeds to test whether or not the load sensor is greater than maximum load count, as indicated at 88. If the load sensor is greater than the maximum permitted load sensor count, the variable load sensor is set equal to the maximum load count, as indicated at 90. If the load count is between the minimum and maximum levels, step function is then calculated, as indicated at 92, as being equal to the load sensor offset plus load sensor slope times load sensor count, all divided by 100. The retarder stage is then set equal to the predetermined retarder threshold constant plus the step function calculated at 92, as indicated at 94. The retarder stage is a pressure that is equivalent to the pressure request generated by the brake treadle signal generator 18.

Referring now to Figure 5b, the treadle voltage generated by operation of the brake treadle generator 18 is then compared with the retarder stage variable calculated at 94 in Figure 5a. If the treadle voltage is less than the retarder stage, as indicated at 96, the retarder level, as indicated at 98, is set equal to zero. If the treadle voltage is greater than the retarder stage, the retarder stage is set to a preliminary level of one, as indicated at 98. The retarder stage is then recalculated as equal to the previous retarder stage plus the step calculated at 92 as indicated at 100. The result is then tested, as indicated at 102, to determine if the treadle voltage is greater than the retarder stage variable calculated at 100. If it is, the retarder level is set at retarder level two, as indicated at 104. The retarder stage variable is then recalculated, as indicated at 106, by again adding the step calculated at 92 to the previous value of the retarder stage variable. This result is tested, as indicated at 108, to determine if the treadle voltage is larger than the retarder stage variable. If it is, the retarder level is set at the retarder level three, as indicated at 110. As indicated at 112, the retarder stage variable is again recalculated by again adding the step variable calculated at 92 to the previous value of the retarder stage variable. The treadle voltage is again tested, as indicated at 114, to determine if it is greater than the retarder stage variable. If it is, the retarder stage is equal to the retarder level four, as indicated at 116. After setting the retarder level zero at 98, or after the program has proceeded through the other branch through the boxes 98-116, the retarder level determined by the foregoing calculation is compared with the retarder level set by the operator by manipulating the switches 26a-d, as indicated at 118. The program then proceeds to test for wheel lockup before sending the retarder program back to the main routine. This is done with reference to Figure 6.

If the braking system is controlled by the adaptive braking subroutine, or if the wheels controlled by the retarder are about to lock up due to the effects of the retarder, it is not desirable to use the retarder to stop the vehicle. Instead, it is desirable to stop the vehicle by using the fluid pressure braking system, which is under control of the antiskid subroutine. Once the incipient skidding condition has passed, control can be retained until the vehicle operator releases the treadle 18, or retarder control can be reintroduced in timed stages.

Referring to Figure 6, the antiskid test indicated at 120 proceeds to obtain the retarder level calculated, as indicated at 122, from the subroutine illustrated in Figures 5a, 5b. The program then proceeds to 124, where it calls the subroutine illustrated in Figure 7, to detect for retarder antiskid. The program then tests, as indicated at 126, to determine if antiskid is active on the rear wheels. If antiskid is active, the retarder level is set at zero, as indicated at 128.

Referring to Figure 7, the test for retarder antiskid is illustrated, beginning at 130. It is, of course, possible to be retarding the vehicle through applications of the switch 26a-d without the brake treadle signal generator 18 being activated. In that case, upon activation of the fluid pressure braking system, it is not desirable to set an additional retarder stage if an incipient skidding condition of the driven wheels exists. Accordingly, a test is made, as indicated at 132 to determine if the brake treadle signal generator 18 has been activated. If the treadle 18 has been activated, a test is made at 134 to determine if the aforementioned antiskid subroutine has been called to control braking many of the driven wheels. If any of the driven wheels are being controlled by the antiskid subroutine, the program returns to the program illustrated Figure 6 as a positive for the test made at 126, so that retarder level will be set at zero. If the driven wheels are not in antiskid with the brake on, the return is negative for the test made at 126 in Figure 6. If the brake is not on, a front reference velocity is calculated as indicated at 140 as equal to the average of the front wheel speeds. A test is then made, as indicated at 142, to determine if any of the rear wheel speeds are less than the front reference. If both rear or driven wheel speeds are greater than the front reference, the program returns positive. If any of the rear wheels are less than the front reference, a slip function is calculated, as indicated at 144, as equal to the difference between the front reference minus the speed of each rear wheel controlled by the controllers 36b and 36c times 100 divided by the front reference speed. As indicated at 146, the slip function is tested to determine if it is greater than a predetermined arbitrary retarder antiskid slip level. If it is, the return is negative as indicated at 138; if it is not, the return is positive as indicated at 136.

Accordingly, the retarder level returned to the main program through Figure 6 will be zero if the brake treadle signal 18 has been activated and if either of the rear driven wheels are controlled by the antiskid subroutine, or if the brake signal generator is not actuated and the retarder has been applied and the rear wheels are about to lock up. The retarder level calculated by Figures 5, 6 and 7 is then used to actuate the retarder relays 30a-d depending upon which of the retarder levels has been selected by the vehicle operator by manipulating the switches 26a-d or has been calculated. The program then calculates the braking pressure to be transmitted to the rear or driven wheel brake actuators, taking into account the retardation level provided by the retarder. This is done through the subroutine illustrated in Figure 3.

Referring now to Figure 8, an alternate control subroutine for a vehicle equipped with a variable, instead of a staged, retarder is illustrated. A variable retarder is similar to a staged retarder, except that the retardation level may be varied continuously instead of requiring that a stage be selected. In this case, the retarder apportioning is calculated at indicated at 148, by first determining if the brake is applied, as indicated at 150. The retarding percentage is then calculated, as indicated at 152. The retarder percentage may be adjusted manually by the vehicle operator, by moving a continuously variable dial, or the retarding percentage may be calculated in much the same way as the upper stage of the stage retarder is calculated using the subroutines illustrated in Figures 5-7. The only difference is that the retardation is calculated as a direct function of vehicle load, instead of in step increments as illustrated in Figure 5. Once the retarding percentage is determined, the brake pressure is calculated, as indicated at 154, as being equal to the brake pressure level demanded by the vehicle operator by operation of the signal generator 18, minus the retarding percentage times the maximum retarder adjustment. A test is made for the engine brake as indicated at 156; if the engine brake is on, a further adjustment is made for the engine brake as indicated at 158. A test is then made to determine if the brake pressure which should be sent to the fluid pressure actuators on the driven wheels is less than zero, as indicated at 160. If this brake pressure is less than zero, it is set equal to zero as at 162, but otherwise the brake pressure is returned to the calling routine as indicated at 164. The retarder percentage which is calculated as a function of vehicle load then is used to control a continuously variable actuator which controls the retarding percentage of the retarder, in a manner well known to those skilled in the art.

Claims

1. Method of controlling retardation of a vehicle having a fluid pressure braking system, said vehicle also having a settable vehicle retarder separate from said vehicle fluid pressure braking system, said braking system including fluid pressure operated brakes controlling the wheels of the vehicle also controlled by said retarder comprising the steps of generating a braking pressure request signal as a function of the braking level requested by the vehicle operator, characterized in that said method includes the steps of generating a retarder setting signal representing the braking pressure equivalent of an established retarder setting, calculating a difference signal varying in accordance with the difference between the braking pressure request signal and the retarder setting signal, and generating a brake pressure level in the fluid pressure operated brakes as a function of said difference signal if said difference signal is greater than zero.

2. Method of controlling retardation of a vehicle having a fluid pressure braking system as claimed in Claim 1, further characterized in that said retarder setting is established by generating a retarder setting signal as a function of vehicle load, comparing said retarder setting signal with said braking pressure request signal, and setting said retarder at a level providing a vehicle retardation equal to or less than the equivalent retardation provided by the braking pressure corresponding to the braking pressure request signal.

3. Method of controlling retardation of a vehicle having a fluid pressure braking system as claimed in Claims 1 or 2, further characterized in that said retarder is a staged retarder settable in one or more discreet stages, each of said stages providing a predetermined retardation of the vehicle, said step of setting the level of the retarder including the step of setting the retarder at a stage providing a retardation closest to, but less than, the braking pressure level established by the braking pressure request signal.

4. Method of controlling retardation of a vehicle having a fluid pressure braking system as claimed in Claims 1 or 2, further characterized in that said retarder is a continuously variable retarder and the step of setting the level of the retarder includes the step of setting the retarder as a function of the braking pressure request signal and vehicle load until the maximum retardation level of the retarder is set, said difference signal being generated only after additional retardation is required after the maximum retardation level of the retarder has been set.

5. Method of controlling retardation of a vehicle having a fluid pressure braking system as claimed in any of the preceding claims, including the step of determining an incipient skidding condition of one or more of the vehicle wheels controlled by said retarder, and setting a zero retardation level of said retarder when said incipient skidding condition exist upon generation of the braking pressure request signal whereupon said difference signal is generated solely as a function of said braking pressure request signal.

6. Method of controlling retardation of a vehicle having a fluid pressure braking system as claimed in any of the preceding claims, including means for manually setting the retardation level of the retarder, said difference signal being set as a function of the manually set retardation level instead of the retarder setting signal when the retardation level of the retarder has been manually set.

7. Apparatus for controlling retardation of a vehicle having a settable vehicle retarder separate from a vehicle fluid pressure braking system, said braking system including fluid pressure operated brakes controlling the wheels of the vehicle also controlled by said retarder comprising operator-actuated means (18) for generating a braking request signal as a function of the braking level requested by the vehicle operator, modulating means (36a-d,38a-d) for setting a brake pressure level in said brakes as a function of a brake pressure control signal, and a

microprocessor (12) receiving said request signal, characterized in that said retarder is set by a retarder control signal, and in that said microprocessor (12) generates said brake pressure control signal and said retarder control signal as a function of the braking request signal.

8. Apparatus for controlling retardation of a vehicle as claimed in Claim 7, further characterized in that said apparatus includes load sensing means (28) for generating a loading signal which varies as a function of the load carried by the vehicle, said microprocessor (12) receiving said loading signal and generating at least one of said control signals as a function of the loading signal.

9. Apparatus for controlling retardation of a vehicle as claimed in Claim 8, further characterized in that said one signal is the retarder control signal.

10. Apparatus for controlling retardation of a vehicle as claimed in any of the preceding claims, further characterized in that said apparatus includes switch means (26) for manually setting said retarder independently of said braking request signal for optional use by the vehicle operator, said microprocessor (12) including means responsive to said switch means (36) for generating said brake pressure control signal as a function of the switch means and the braking request signal.

11. Apparatus for controlling retardation of a vehicle as claimed in any of the preceding claims, further characterized in that said apparatus includes wheel speed sensing means (44a-d), said microprocessor (12) including means responsive to said wheel speed sensing means (44a-d) for establishing when an incipient skidding condition exists, said microprocessor (12) further including means for inhibiting said retarder control signal and causing the braking pressure established by said braking request signal to be communicated to said brakes when an incipient skidding condition exists.

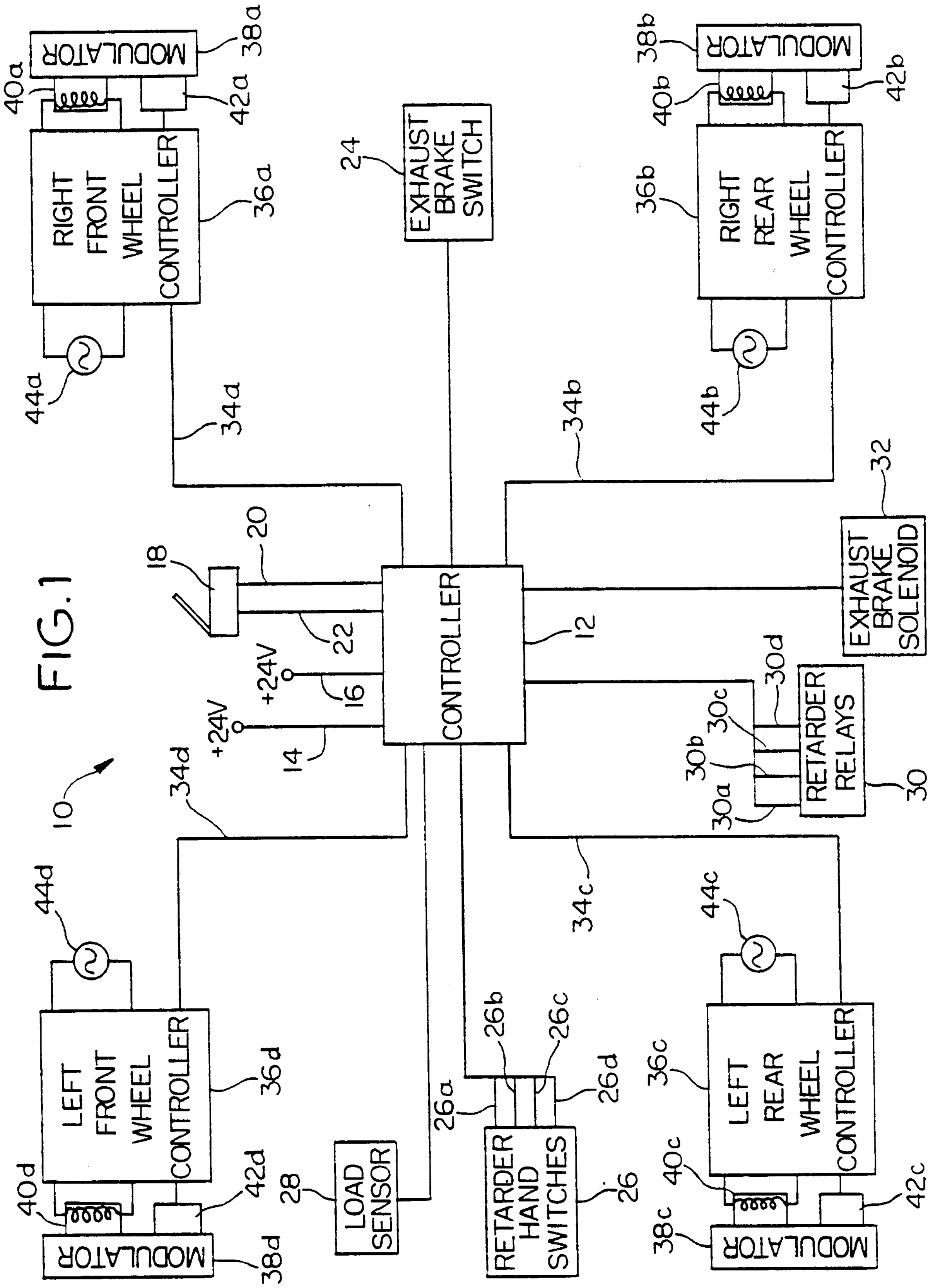

MODULATOR
38a
40a
42a
RIGHT
FRONT
WHEEL
CONTROLLER
36a
44a
34a
EXHAUST
BRAKE
SWITCH
24
MODULATOR
38b
40b
42b
RIGHT
REAR
WHEEL
CONTROLLER
36b
44b
34b
32
EXHAUST
BRAKE
SOLENOID
18
20
22
CONTROLLER
12
+24V
16
+24V
14
RETARDER
RELAYS
30
30a
30b
30c
30d
10
34d
34c
44d
LEFT
FRONT
WHEEL
CONTROLLER
36d
40d
42d
MODULATOR
38d
LOAD
SENSOR
28
RETARDER
HAND
SWITCHES
26
26a
26b
26c
26d
44c
LEFT
REAR
WHEEL
CONTROLLER
36c
40c
42c
MODULATOR
38c

FIG. 1

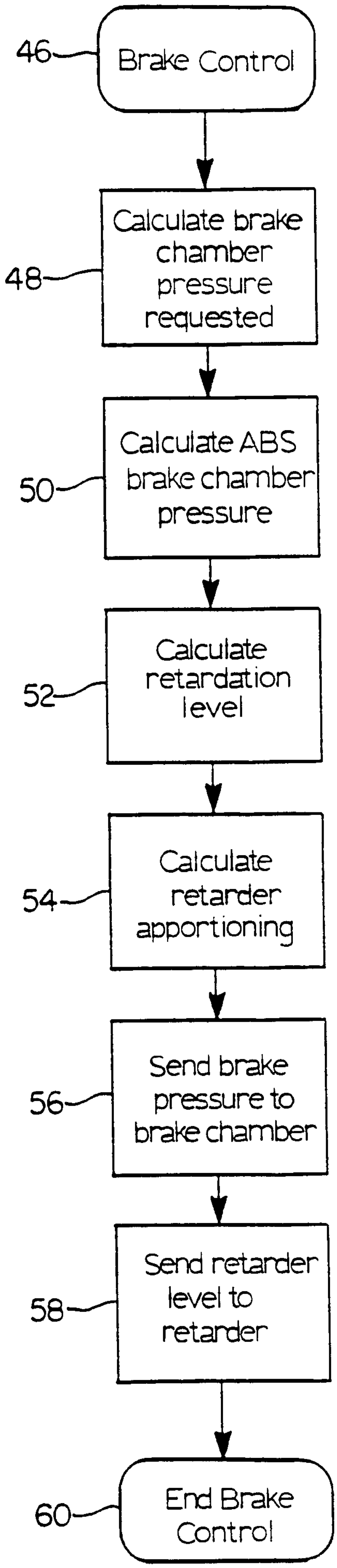
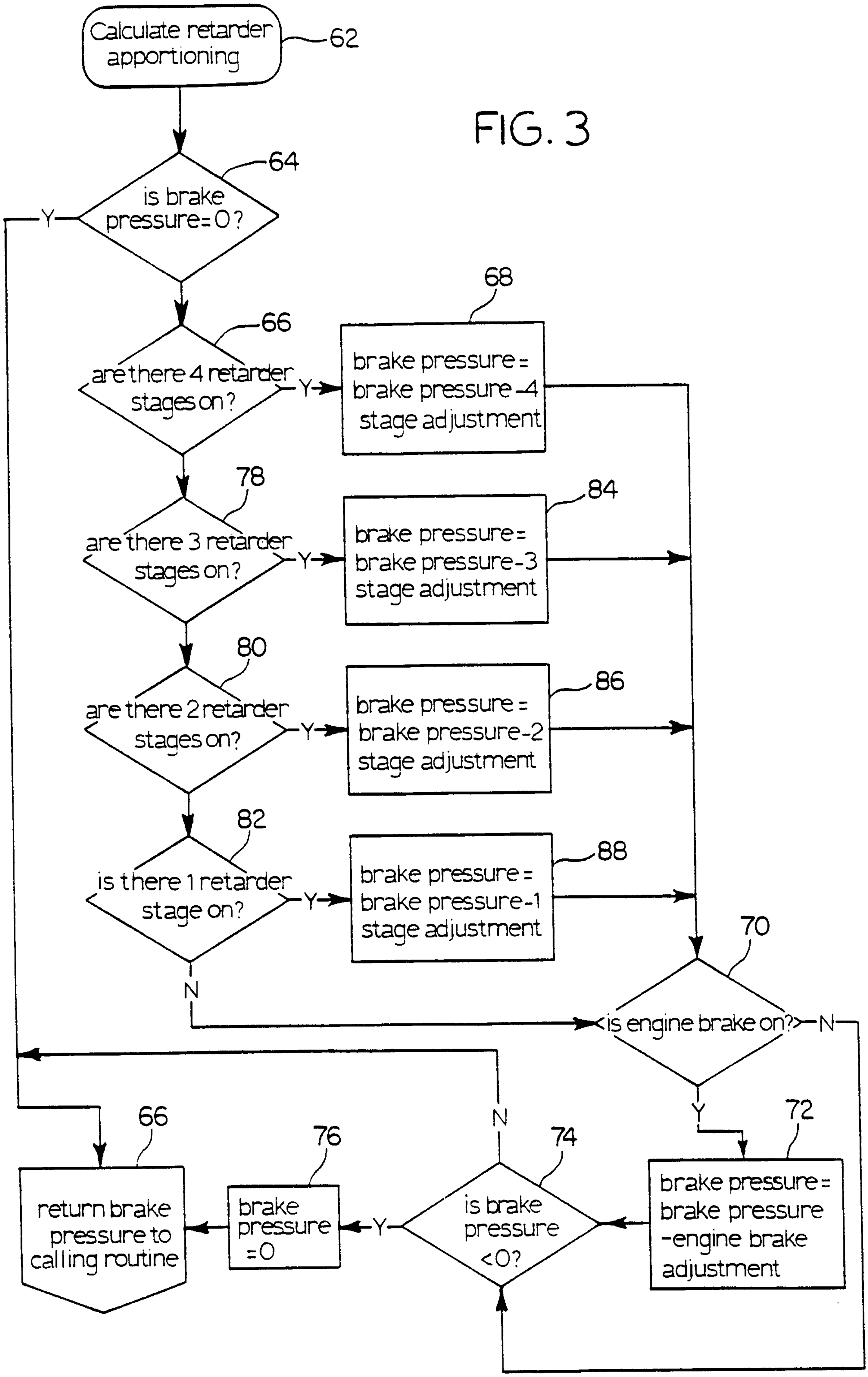

46
Brake Control
48
Calculate brake chamber pressure requested
50
Calculate ABS brake chamber pressure
52
Calculate retardation level
54
Calculate retarder apportioning
56
Send brake pressure to brake chamber
58
Send retarder level to retarder
60
End Brake Control

FIG. 2



Calculate retarder apportioning
62
64
is brake pressure=0?
Y
66
are there 4 retarder stages on?
Y
68
brake pressure = brake pressure -4 stage adjustment
78
are there 3 retarder stages on?
Y
84
brake pressure = brake pressure-3 stage adjustment
80
are there 2 retarder stages on?
Y
86
brake pressure = brake pressure-2 stage adjustment
82
is there 1 retarder stage on?
Y
88
brake pressure = brake pressure-1 stage adjustment
N
70
is engine brake on?
N
Y
72
brake pressure = brake pressure -engine brake adjustment
74
is brake pressure <0?
N
Y
76
brake pressure =0
66
return brake pressure to calling routine

FIG. 3

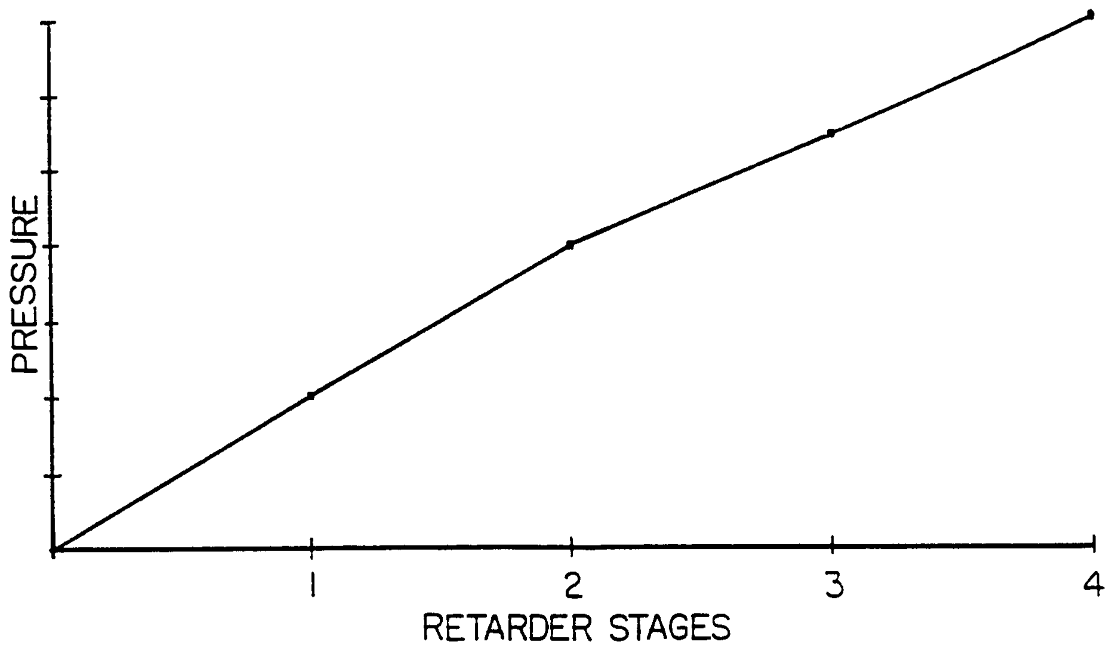


FIG.4

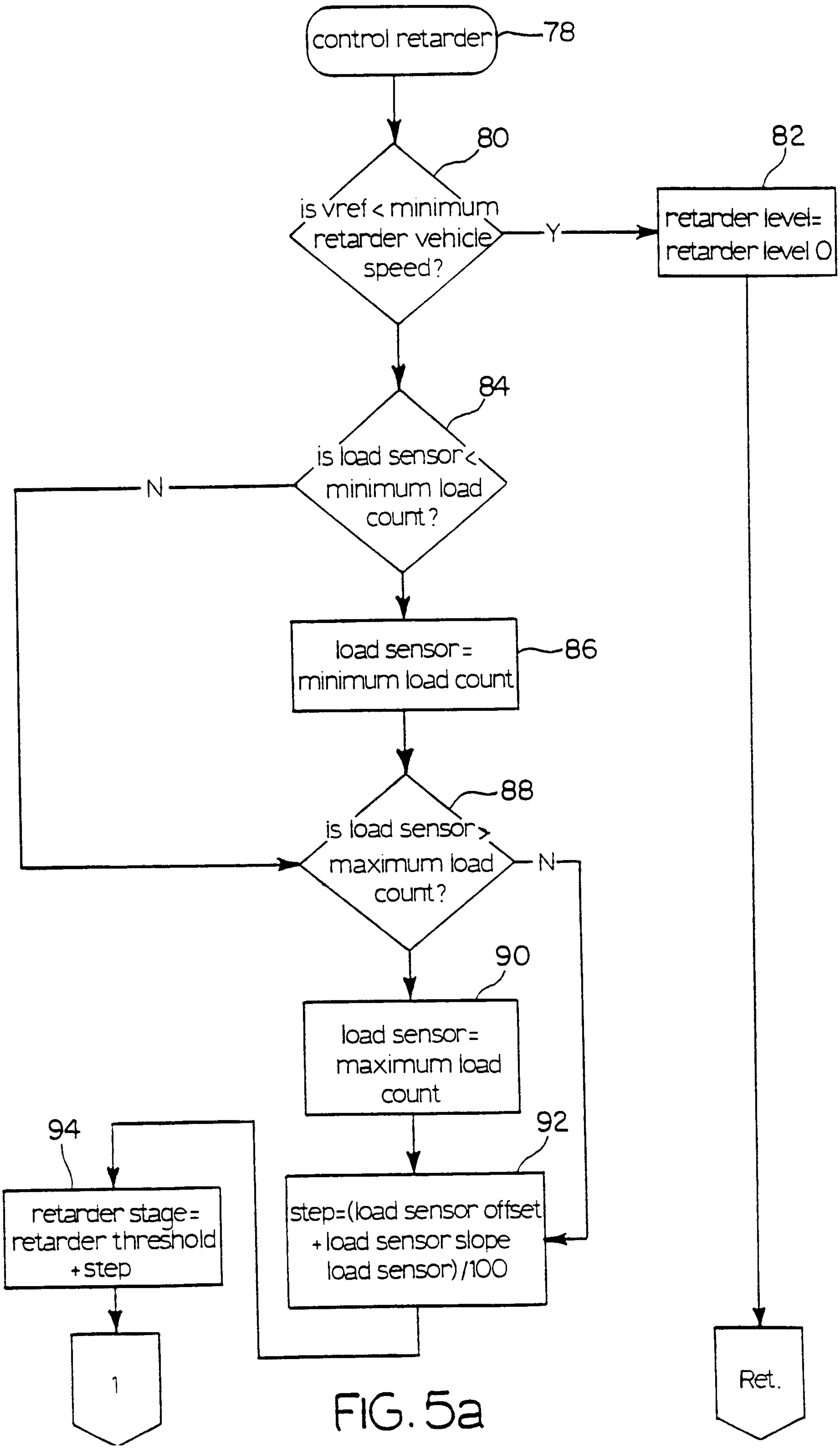
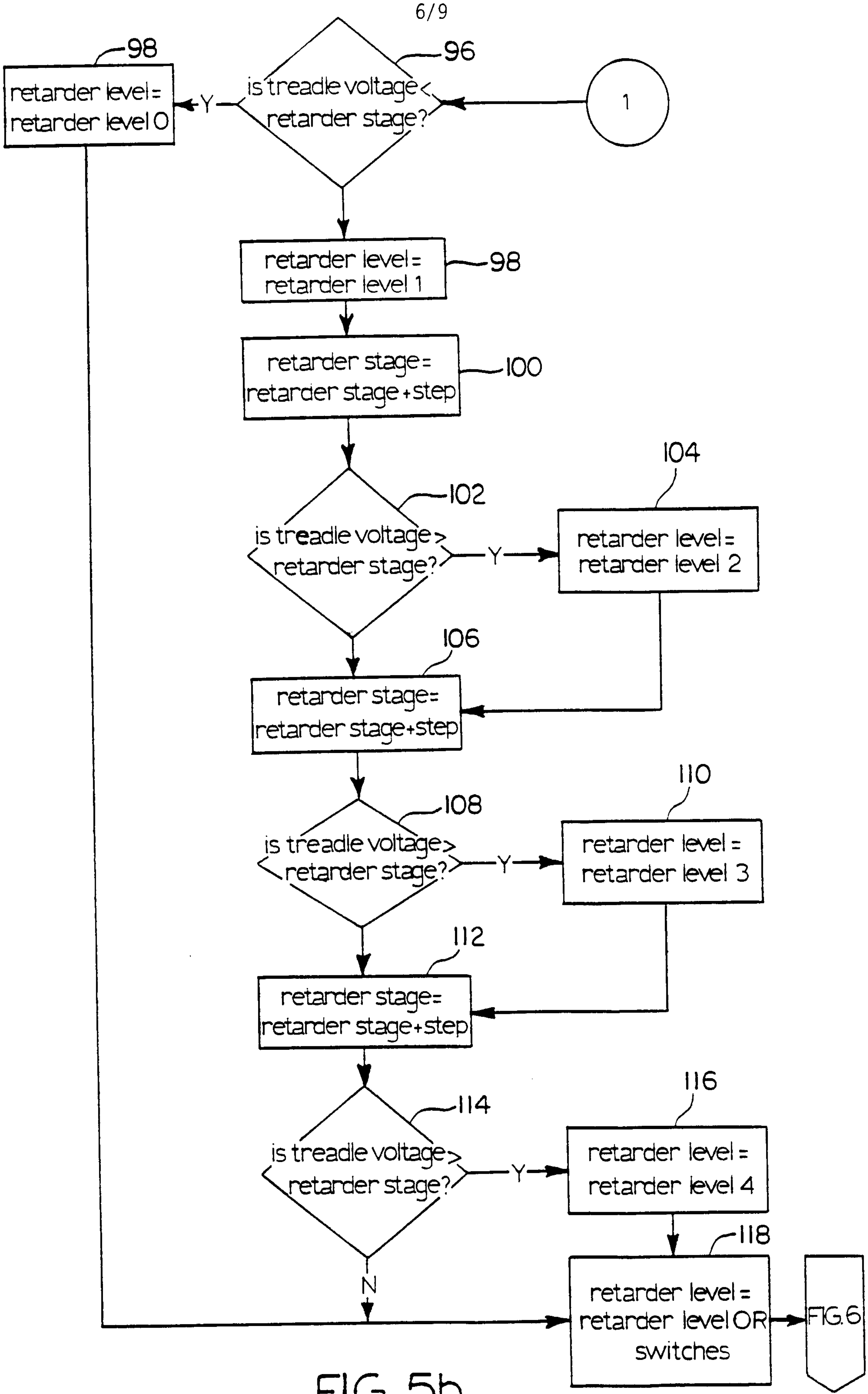

control retarder
78
80
is vref < minimum retarder vehicle speed?
Y
82
retarder level= retarder level 0
84
is load sensor < minimum load count?
N
load sensor = minimum load count
86
88
is load sensor > maximum load count?
N
90
load sensor= maximum load count
92
step=(load sensor offset + load sensor slope load sensor)/100
94
retarder stage= retarder threshold + step
1
Ret.

FIG. 5a



98
retarder level = retarder level 0
Y
is treadle voltage < retarder stage?
96
1
retarder level = retarder level 1
98
retarder stage = retarder stage + step
100
is treadle voltage > retarder stage?
102
Y
104
retarder level = retarder level 2
106
retarder stage = retarder stage + step
108
is treadle voltage > retarder stage?
Y
110
retarder level = retarder level 3
112
retarder stage = retarder stage + step
114
is treadle voltage > retarder stage?
Y
116
retarder level = retarder level 4
N
118
retarder level = retarder level OR switches
FIG.6

FIG. 5b

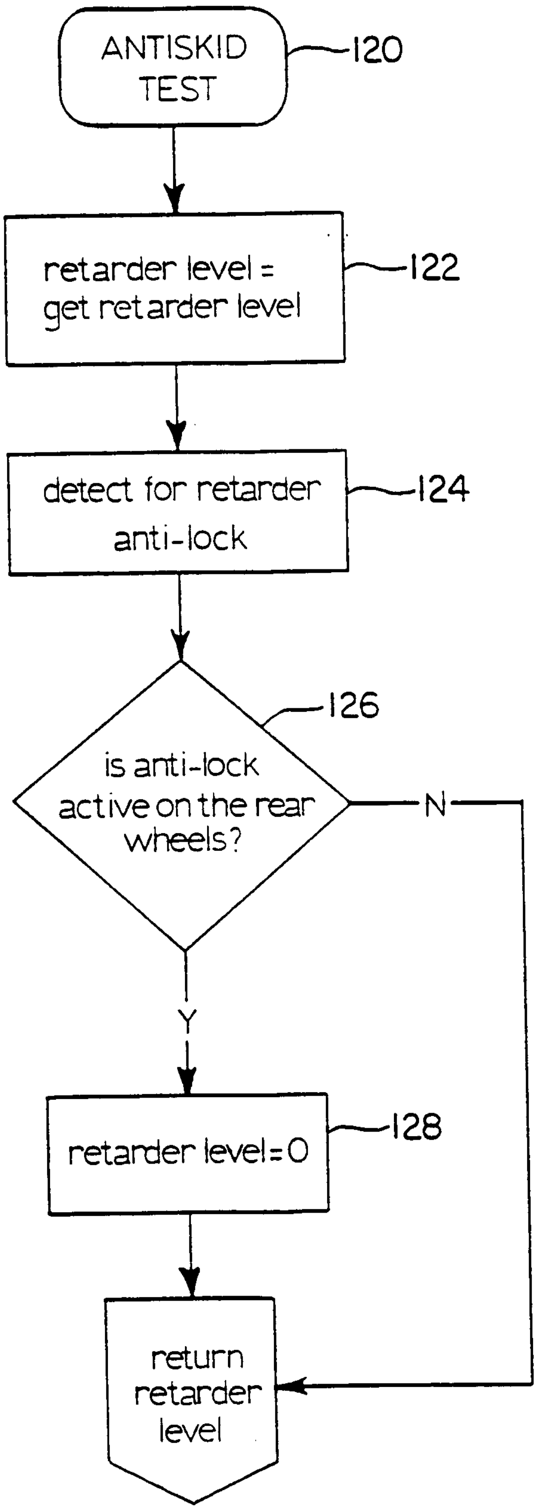

ANTISKID
TEST
120
retarder level =
get retarder level
122
detect for retarder
anti-lock
124
126
is anti-lock
active on the rear
wheels?
N
Y
retarder level=0
128
return
retarder
level

FIG.6

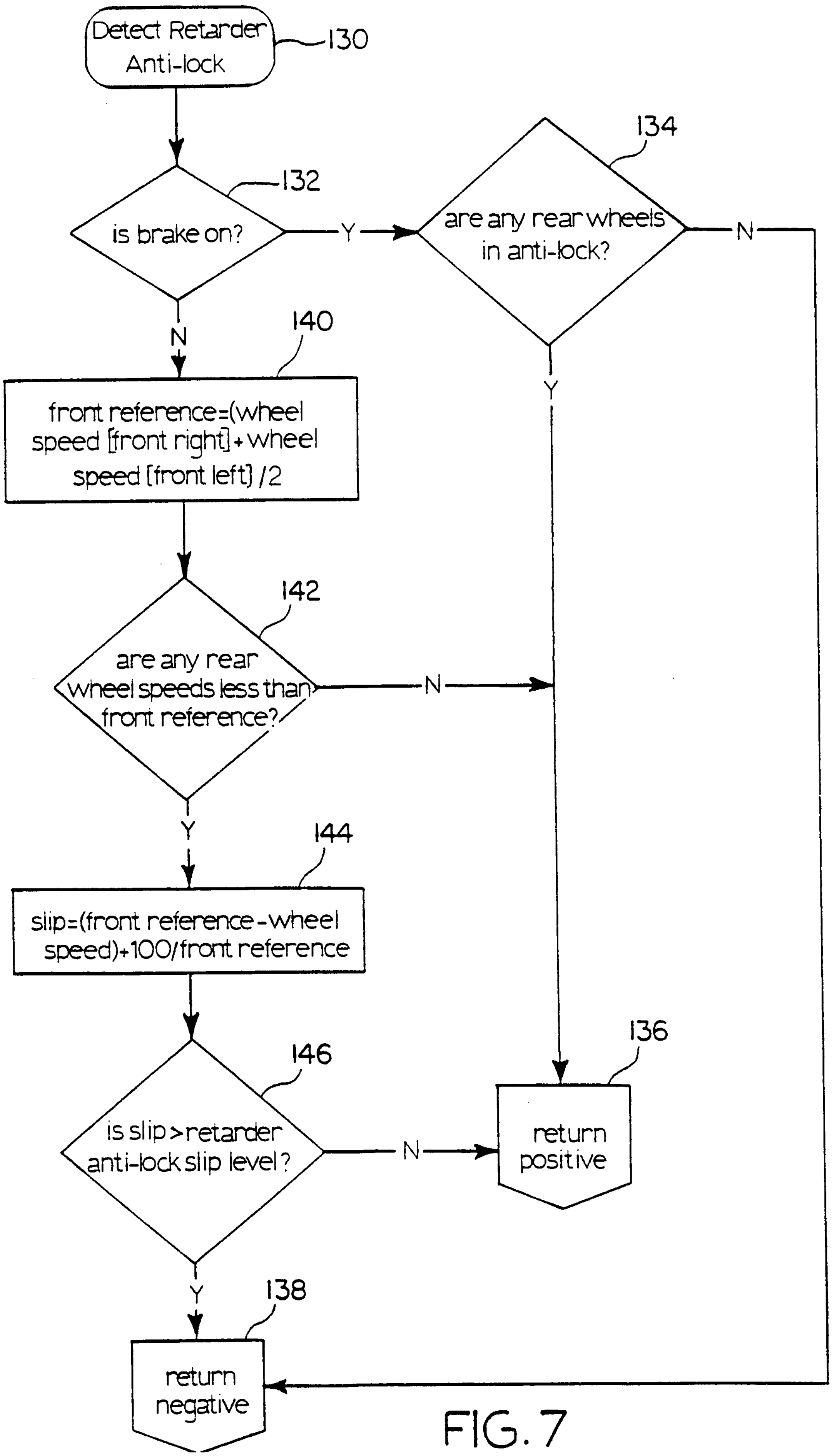

Detect Retarder Anti-lock
130
is brake on?
132
Y
are any rear wheels in anti-lock?
134
N
N
140
front reference=(wheel speed [front right]+wheel speed [front left] /2
Y
are any rear wheel speeds less than front reference?
142
N
Y
144
slip=(front reference-wheel speed)+100/front reference
is slip>retarder anti-lock slip level?
146
N
return positive
136
Y
138
return negative

FIG. 7

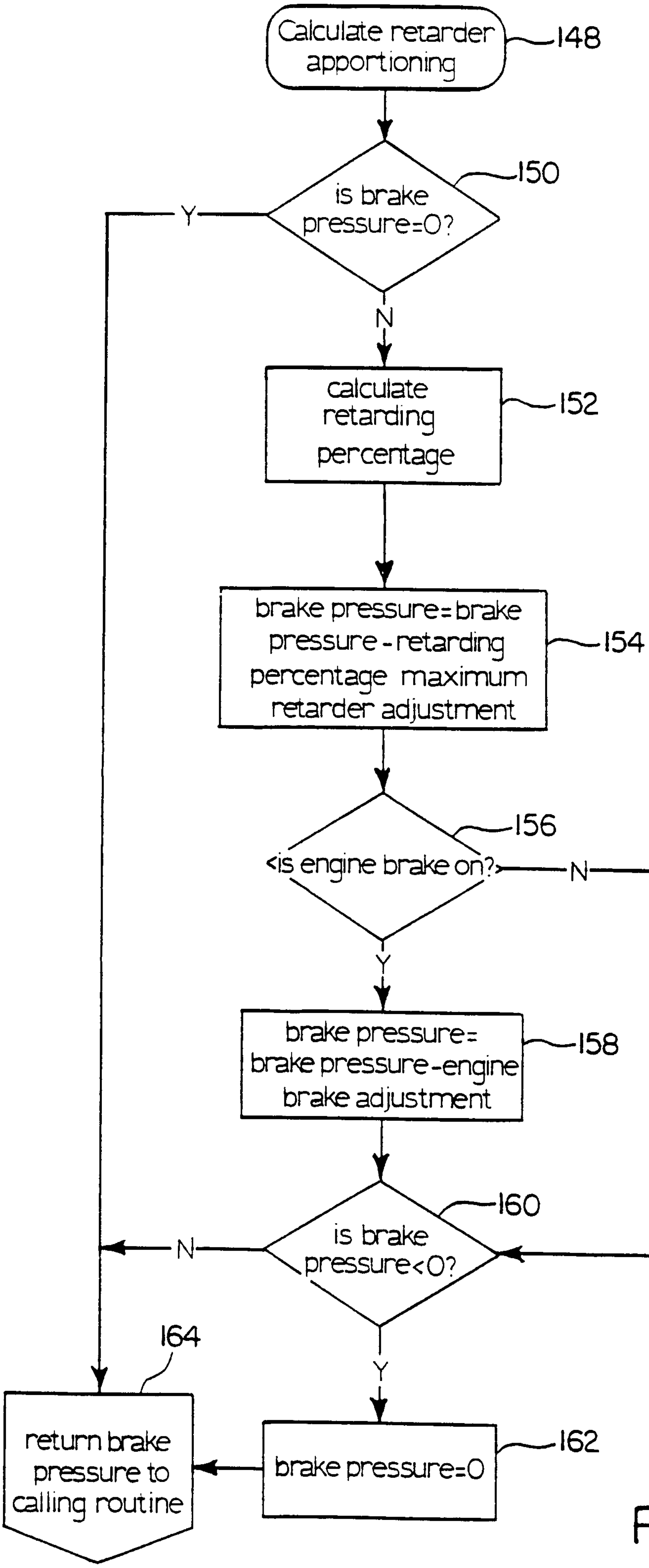

Calculate retarder apportioning
148
is brake pressure=0?
150
Y
N
calculate retarding percentage
152
brake pressure=brake pressure - retarding percentage maximum retarder adjustment
154
<is engine brake on?>
156
N
Y
brake pressure= brake pressure-engine brake adjustment
158
is brake pressure<0?
160
N
Y
164
return brake pressure to calling routine
brake pressure=0
162

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 94/01100

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 B60T13/58 B60T13/66 B60T8/26 B60T8/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 B60T

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 361 708 (FORD) 4 April 1990	1,2,4, 7-9
	see page 2, line 35 - page 6, line 9; claims 8-11; figures 1-8	
Y		3,5,6, 10,11

Y	EP,A,0 241 872 (CSEPEL AUTOGYÁR) 21 October 1987 see page 2, line 12 - page 3, line 23 see page 6, line 10 - line 22; figure 1 ---	5,11
Y	FR,A,2 108 951 (LABAVIA) 26 May 1972 see page 3, line 29 - page 4, line 11; figure 1 ---	3,6,10
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
4 May 1994	26.05.94.

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Meijs, P

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GLASERS ANNALEN (ZEV), no.112, April 1988, BERLIN (GERMANY) pages 119 - 124, XP000020462 WAGNER, LOHMEIER 'ELEKTRODYNAMISCHES BREMSEN IN VERBINDUNG MIT DER STEUERUNG FÜR REIBUNGSBREMSEN' see page 122, left column, paragraph 1 - page 123, right column, paragraph 2 see page 124, left column, last paragraph - right column, paragraph 1; figures 6-8,10,13 ---	1,2,7,8
X	US,A,4 188 070 (GRENIER) 12 February 1980 see column 2, line 41 - column 3, line 20 see column 4, line 36 - column 5, line 13; figure 1 ---	1,7
X	DE,A,34 40 081 (ALFRED TEVES) 7 May 1986 see page 6, last paragraph - page 8, paragraph 2; figure ---	1
A	US,A,3 966 008 (KLAUE) 29 June 1976 see abstract see column 2, line 12 - line 18 see column 2, line 45 - line 52 see column 2, line 57 - line 61 see column 6, line 4 - line 57 see column 7, line 10 - line 68; figures 4,6,7 ---	1,5,7,11
A	DE,A,31 06 699 (WABCO WESTINGHOUSE) 9 September 1982 see page 2, line 8 - page 4, line 25; figure 1 -----	3,5,6, 10,11

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US 94/01100

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		CA-A-	1325392	21-12-93
		DE-D-	68912863	17-03-94
		JP-A-	2120165	08-05-90
EP-A-0241872	21-10-87	NONE		
FR-A-2108951	26-05-72	NONE		
US-A-4188070	12-02-80	NONE		
DE-A-3440081	07-05-86	NONE		
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		DE-A-	2317358	18-10-73
		FR-A,B	2171412	21-09-73
		GB-A-	1375348	27-11-74
		US-A-	3870118	11-03-75
		DE-A-	2235003	15-03-73
		FR-A,B	2108205	19-05-72
		GB-A-	1361278	24-07-74
		CH-A-	545430	31-01-74
		DE-A-	2041867	02-03-72
DE-A-3106699	09-09-82	NONE		