

PATENT SPECIFICATION

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(54) BRAKE SYSTEM

(71) We, CATERPILLAR TRACTOR Co., a corporation organized and existing under the Laws of the State of California, United States of America, of 100 N.E. Adams Street, Peoria, State of Illinois 61629, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

A common form of vehicle service brake system employs a master cylinder which may be operated to transmit a fluid pressure to individual brakes at each of the vehicle wheels for the purpose of applying the brakes. Heavy trucks, earthmoving vehicles and the like often have a pneumatic circuit for actuating the master cylinder or cylinders in response to manipulation of an operator's brake control. It is customary to supplement the service brake system with an emergency brake system which may be independent of or an integral part of the service brake system.

In many cases, the emergency brake is of the spring applied, fluid pressure released, type for braking the rear wheels only. Such emergency brakes are generally automatically applied by the actuating springs upon loss of fluid pressure in the service brakes. While this is fundamentally a valuable safety measure it can also complicate the operator's task. If conditions permit, the operator would generally prefer to bring the vehicle to a more controlled emergency stop by modulated controllable braking rather than by suddenly having the brakes locked on, out of manual control. Furthermore, under certain conditions, it is desirable to be able simultaneously to actuate the emergency brake on the rear wheels along with the front service brakes for additional braking power. However, this has not heretofore been possible since the front

brakes are applied by an increase in fluid pressure and the rear brakes are only applied by a loss of fluid pressure.

According to the present invention a vehicle brake system for stopping rotation of two independently rotatable elements comprises a fluid pressure applied brake operatively associated with one of the rotatable elements, a spring applied, fluid pressure released brake operatively associated with the other of the rotatable elements, a pressurized fluid supply system connected to both brakes, and a valve system normally positioned to direct pressurized fluid to the spring applied, fluid pressure released brake whilst blocking fluid flow to the fluid pressure applied brake thus releasing both of the brakes permitting unrestricted rotation of the two elements, the valve system having a valve selectively positionable to cause fluid flow to the spring applied, fluid pressure released brake to be blocked and to cause pressurized fluid be directed to the fluid pressure applied brake so that both of the brakes are applied for stopping rotation of the rotatable elements.

The invention provides an improved brake system of the character described above which gives operator control over the actuation of the automatically applicable brake in combination with a separate brake device for simultaneous actuation of both brake devices.

One example of a brake system according to the invention will now be described with reference to the accompanying drawing, which is a schematic representation of a brake system.

Referring more particularly to the drawing, a brake system embodying the principles of the present invention is generally indicated by the reference numeral 10 in association with a pair of front wheels 11 of a vehicle, not shown, and a pair of rotatable

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shafts 12 each of which is operatively associated with a rear wheel, not shown, for such a vehicle. A pair of fluid pressure applied front brake mechanisms 13 are individually
5 operatively associated with the front wheels 11 for stopping rotation hereof in the usual manner. A pair of rear brake mechanisms 14 are individually associated with the rotatable shafts 12 for stopping rotation thereof
10 when the brakes are applied.

Each of the rear brake mechanisms 14 includes a non-rotatable housing 16 having an end wall 17. A first annular piston 18 is disposed within the housing and adapted to
15 clamp a plurality of alternately interleaved stationary and rotatable discs 19 against the end wall 17 for stopping rotation of the shaft 12. An actuating chamber 21 is formed between the first piston and the housing and
20 is adapted to receive pressurized fluid to move the piston toward the end wall as will hereinafter be described. A second annular piston 22 is disposed within the housing and is resiliently urged into abutting engagement
25 with the first piston by a plurality of springs 23 such that the discs are clamped against the end wall. An actuating chamber 24 is formed by the second piston and the housing and is adapted to receive fluid to move the
30 second piston against the bias of the springs for freeing the first piston, which is retracted by return springs, not shown.

Actuation of the front and rear brake mechanisms 13 and 14 is controlled through
35 a control system 26 having a service brake circuit 27, a retarder circuit 28, and an emergency brake and parking circuit 29. An air tank 32 is common to both the service brake circuit and the retarder circuit
40 and stores pressurized fluid directed thereto through a check valve 33 from a compressor, not shown. The service brake circuit includes a first air actuated relay valve 34 disposed within a line 36 connecting the air
45 tank with a master cylinder 37 and is normally resiliently positioned for blocking air flow through the line. A second air actuated relay valve 38 is disposed within a line 39 connecting the air tank with a double
50 check valve 42 and is normally resiliently positioned for blocking air flow through the line. A manually controllable service brake valve 43 is disposed within a line 44 connecting the air tank with one end of the first
55 relay valve 34 and is normally resiliently positioned for blocking flow of actuating air to the first relay valve. A branch line 45 connects the line 44 between valves 43 and 34 with one end of the second relay valve
60 38. A manually actuatable on-off valve 46 is disposed within the line 45 for controlling flow of actuating air to the second relay valve.

The master cylinder 37 is of the usual
65 type having an air chamber 50 connected to

the line 36 and a fluid chamber 51 separated from the air chamber by a stepped actuator piston 52. A conduit 53 connects the fluid chamber with a double check valve 54 which
in turn is connected by a conduit 56 to the
70 actuating chambers 21 of the rear brake mechanisms 14. The fluid chamber is also connected to a makeup tank 57 through
check valve 58.

A line 59 connects the check valve 42 with
75 an air chamber 61 of a master cylinder 62. A fluid chamber 63 of the master cylinder is separated from the air chamber by a stepped piston 64 and is connected to the front brake mechanisms 13 through a conduit 66. A
80 fluid makeup tank 67 is connected to the fluid chamber through a check valve 68.

The retarder circuit 28 includes an air actuated relay valve 69 disposed within a
85 line 70 connecting the air tank 32 with an air chamber 71 of a master cylinder 72. A manually positionable control valve 73 is disposed within a line 74 connecting the air tank with one end of the relay valve 69. A
90 fluid chamber 76 is separated from the air chamber by a stepped piston 77 and is connected to the double check valve 54 by a conduit 78 which has a two-position manual towing valve 79 disposed therein.
95 The towing valve is normally suitably retained in the position shown to permit fluid flow through the conduit 78 to the double check valve.

The emergency and parking brake circuit
100 29 includes an air actuated modulating valve 82 disposed within a conduit 83 connecting a pump 84 with the actuating chambers 24 of the brake mechanisms 14. The modulating valve is normally resiliently positioned
105 to communicate the actuating chambers with a tank 85. A check valve 86 is disposed within the conduit 83 between the pump and the modulating valve. A normally closed pressure switch 87 is in communication with the conduit 83 and controls an electrical
110 circuit to a warning light 88. A manual emergency valve 89 and a parking valve 91 are disposed in series within a line 92 which is connected to and transmits actuating air from an air tank 93 to one end of the modulating
115 valve 82. The air tank receives pressurized air from the compressor, not shown, through a check valve 94. An air actuated inversion valve 96 is disposed within a line 97 connecting the air tank 93 with the double
120 check valve 42 and is normally resiliently positioned to permit air flow therethrough. A line 98 is connected to the line 92 between the manual emergency valve and the parking brake valve and communicates
125 actuating air from the manual emergency valve to one end of the inversion valve.

The relay valves 34, 38 and 69, inversion valve 96, the service brake valve 43, the retarder valve 73, and the emergency brake
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valve 89 are of the type wherein air flow therethrough is selectively modulatable. Likewise the modulating valve 82 is constructed for modulating fluid flow there-through.

While the operation of the present invention is believed clearly apparent from the foregoing description, further amplification will subsequently be made in the following brief summary of such operation. The air compressor and the pump 84 are driven by the vehicle engine in the usual manner such that the air tanks 32 and 93 are pressurized by the air compressor automatically after the engine is started and fluid from the pump is directed to the modulating valve 82. The valves 89 and 91 are normally in the position shown so that pressurized air is transmitted through line 92 to shift the modulating valve to a position for communicating the pump 84 with the chambers 24 of the brake mechanisms 14 through the conduit 83. The fluid in these chambers moves the second pistons 22 against the bias of the springs 23 and frees the first piston 18 for normal service brake operations.

Manually positioning the on-off valve 46 permits the operator to choose between service braking with the rear brake mechanisms 14 only or the combination of both front and rear brake mechanisms 13 and 14. With the valve 46 in the position shown, only the brake mechanisms 14 are employed for normal service braking which is initiated by manually positioning the service brake valve 43 for directing pressurized air to the end of the first relay valve 34. The first relay valve is in turn shifted to establish communication through line 36 to the air chamber 50 of the master cylinder 37. The pressurized air in the air chamber acts against the piston 52 which pressurizes the fluid in the fluid chamber 51 and directs such fluid through conduit 53, check valve 54 and conduit 56 to the chambers 21 of the rear brake mechanisms for moving the first pistons 18 toward the end walls 17 of the housings 16. The first pistons clamp the discs 19 against the end walls stopping rotation of the shafts 12 and thus the rear wheels. Releasing the service brake valve results in the air chamber 50 being vented to the atmosphere and releases the rear brake mechanisms.

Manually shifting the on-off valve 46 to establish communication through the line 45 results in the simultaneous shifting of both the first and second relay valves 34 and 38, respectively when the service brake valve 43 is manually shifted. Shifting valve 34 causes the rear brake mechanisms 14 to be applied as previously described while shifting the relay valve 38 directs pressurized air through line 39, double check valve 42, and line 59 to the air chamber 61 of the master cylinder

This pressurizes the fluid in the fluid chamber 63 with the fluid being directed to the front brake mechanisms 13 thereby stopping rotation of the wheels 11. Thus, with the on-off valve shifted both brake mechanisms 13 and 14 are applied simultaneously.

Considering now the retarding mode of braking, the control valve 73 is manually shifted to direct pressurized air to the end of the relay valve 69 which in turn is shifted to communicate pressurized air to the air chamber 71 of the master cylinder 72. The control valve 73 is preferably frictionally retarded or detented so that it can be positioned in predetermined increments for precisely controlling the air flow directed to the relay valve and thus to the master cylinder. The air pressure in the air chamber results in pressurization of the fluid in the fluid chamber 76 with the fluid being directed through the conduit 78, the normally open towing valve 79, the double check valve 54, conduit 56 and into the actuating chambers 21 of the rear brake mechanisms 14. The fluid in the actuating chambers moves the first pistons 18 against the discs 19 an amount proportional to the air pressure in the air chamber 71 of the master cylinder. Thus the rear brake mechanisms are applied for the purpose of controlling vehicle speed while travelling down a slope. Returning the control valve 73 to the position shown releases the brake mechanisms to permit rotation of the shafts 12.

The manually controlled emergency braking mode of operation is initiated by manually shifting the manual emergency valve 89 simultaneously to block flow of pressurized actuating air through lines 92 and 98 permitting the modulating valve 82 and the inversion valve 96 to be resiliently shifted toward their normal position. Shifting the modulating valve toward its normal position results in blocking fluid flow from the pump 84 while modulating the exhausting of fluid from the chambers 24 of the brake mechanisms 14. This permits the spring 23 to move the second pistons 22 against the first pistons 18 which clamp the discs 19 against the end plates 17 for stopping rotation of the shafts 12. The shifting of the inversion valve 96 toward its normal position by reducing actuating air pressure thereto results in pressurized air being modulatably directed through line 97, the double check valve 42, line 59, and into the air chamber 61 of the master cylinder 62. This causes pressurized fluid to be directed through the conduit 66 to apply the front brake mechanisms 13 for stopping rotation of the front wheels 11. Thus, both brake mechanisms 13 and 14 are applied simultaneously through the shifting of the manual emergency valve 89.



The rear brake mechanisms 14 may be used as a parking brake by manually shifting the parking brake valve 91. This vents the conduit 92 permitting the modulation valve 82 to shift to a position blocking fluid flow from the pump 84 while exhausting the actuating chambers 24 through the conduit 83. This causes the spring 23 to move the second pistons 22 against the first pistons 18 which in turn clamp the discs 19 against the end plates 17 for preventing rotation of the shafts 12.

Although the brake system 10 is arranged to minimize the probability of the rear brake mechanisms 14 being suddenly applied and out of control of the operator, the rear brake mechanisms are automatically applied under certain conditions for safety reasons. For example, a loss of pressurized fluid from conduit 83 results in automatic application of the rear brake mechanisms. Likewise, a sudden loss of air pressure in the conduit 92 permits the modulating valve 82 to shift to block fluid flow from the pump while exhausting the fluid from chambers 24 and conduit 83 permitting the springs 23 to apply the rear brake mechanisms.

The towing valve 79 is included to provide an alternate source of pressurized fluid for releasing the rear brake mechanisms 14 when fluid pressure is not available from the pump 84 such as when the engine is inoperative. Of course, the towing mode of operation is dependent upon having pressurized air in the air tanks 32 and 93. In some cases sufficient air pressure may remain in the air tanks for the towing operations while in other cases it may be necessary to connect the air tanks to the air systems of the towing vehicle. With air pressure in tank 93, the modulating valve 82 is shifted to permit fluid flow through conduit 83. The towing mode is initiated by shifting the towing valve 79 to connect the conduit 78 to the conduit 83. The control valve 73 of the retarder circuit 28 is then manually shifted to direct actuating air to shift the relay valve 69 which in turn causes pressurized air to be directed to the air chamber 71. This results in pressurized fluid from the fluid chamber 76 being directed through conduit 78, towing valve 79, conduit 83 and into the chambers 24. The pressurized fluid in the chambers moves the second pistons against the bias of the springs 23 to release the clamping force on the discs 19. While the vehicle is being towed, both brake mechanisms 13 and 14 can be applied to stop the vehicle by actuation of the valve 89 as previously described.

In view of the foregoing it is readily apparent that the present invention provides an improved brake system which provides for the simultaneous application of a fluid applied brake and a spring applied fluid re-

leased brake by the manual manipulation of a single control valve. This is accomplished by providing an air actuated modulating valve for controlling fluid flow to the spring applied fluid released brake and an air actuated inversion valve for controlling fluid flow to the fluid applied brake. Reducing the flow of actuation air to the modulating valve causes it to shift toward a position for blocking fluid flow therethrough for supplying the spring applied released brake while reducing the flow of actuating air to the inversion valve causes it to shift toward a position for directing pressurized fluid to apply the fluid applied brake. Thus, by controlling the flow of actuating air to the modulating and inversion valves by a single control valve, both brakes are actuated simultaneously. Also, the spring applied fluid released brake is always available for automatic emergency braking when fluid pressure is lost from the system. Furthermore, the spring applied fluid released brake may be independent of or an integral part of a service brake mechanism with the spring applied fluid release brake providing an emergency brake system to supplement the service brake system.

WHAT WE CLAIM IS:—

1. A vehicle brake system for stopping rotation of two independently rotatable elements, comprising a fluid pressure applied brake operatively associated with one of the rotatable elements; a spring applied, fluid pressure released brake operatively associated with the other of the rotatable elements, a pressurized fluid supply system connected to both brakes, and a valve system normally positioned to direct pressurized fluid to the spring applied, fluid pressure released brake whilst blocking fluid flow to the fluid pressure applied brake thus releasing both of the brakes permitting unrestricted rotation of the two elements, the valve system having a valve selectively positionable to cause fluid flow to the spring applied, fluid pressure released brake to be blocked and to cause pressurized fluid to be directed to the fluid pressure applied brake so that both of the brakes are applied for stopping rotation of the rotatable elements.

2. A brake system according to claim 1, wherein the valve system includes a manual control valve selectively positionable to block the supply of pressurized fluid to the spring applied, fluid pressure released brake, and a fluid actuated inversion valve positioned to direct the pressurized fluid to the fluid pressure applied brake in response to the blocking of the supply of pressurized fluid to the spring applied, fluid pressure released brake.

3. A brake system according to claim 2, wherein the fluid supply system includes a

The rear brake mechanisms 14 may be used as a parking brake by manually shifting the parking brake valve 91. This vents the conduit 92 permitting the modulation valve 82 to shift to a position blocking fluid flow from the pump 84 while exhausting the actuating chambers 24 through the conduit 83. This causes the spring 23 to move the second pistons 22 against the first pistons 18 which in turn clamp the discs 19 against the end plates 17 for preventing rotation of the shafts 12.

Although the brake system 10 is arranged to minimize the probability of the rear brake mechanisms 14 being suddenly applied and out of control of the operator, the rear brake mechanisms are automatically applied under certain conditions for safety reasons. For example, a loss of pressurized fluid from conduit 83 results in automatic application of the rear brake mechanisms. Likewise, a sudden loss of air pressure in the conduit 92 permits the modulating valve 82 to shift to block fluid flow from the pump while exhausting the fluid from chambers 24 and conduit 83 permitting the springs 23 to apply the rear brake mechanisms.

The towing valve 79 is included to provide an alternate source of pressurized fluid for releasing the rear brake mechanisms 14 when fluid pressure is not available from the pump 84 such as when the engine is inoperative. Of course, the towing mode of operation is dependent upon having pressurized air in the air tanks 32 and 93. In some cases sufficient air pressure may remain in the air tanks for the towing operations while in other cases it may be necessary to connect the air tanks to the air systems of the towing vehicle. With air pressure in tank 93, the modulating valve 82 is shifted to permit fluid flow through conduit 83. The towing mode is initiated by shifting the towing valve 79 to connect the conduit 78 to the conduit 83. The control valve 73 of the retarder circuit 28 is then manually shifted to direct actuating air to shift the relay valve 69 which in turn causes pressurized air to be directed to the air chamber 71. This results in pressurized fluid from the fluid chamber 76 being directed through conduit 78, towing valve 79, conduit 83 and into the chambers 24. The pressurized fluid in the chambers moves the second pistons against the bias of the springs 23 to release the clamping force on the discs 19. While the vehicle is being towed, both brake mechanisms 13 and 14 can be applied to stop the vehicle by actuation of the valve 89 as previously described.

In view of the foregoing it is readily apparent that the present invention provides an improved brake system which provides for the simultaneous application of a fluid applied brake and a spring applied fluid re-

leased brake by the manual manipulation of a single control valve. This is accomplished by providing an air actuated modulating valve for controlling fluid flow to the spring applied fluid released brake and an air actuated inversion valve for controlling fluid flow to the fluid applied brake. Reducing the flow of actuation air to the modulating valve causes it to shift toward a position for blocking fluid flow therethrough for supplying the spring applied released brake while reducing the flow of actuating air to the inversion valve causes it to shift toward a position for directing pressurized fluid to apply the fluid applied brake. Thus, by controlling the flow of actuating air to the modulating and inversion valves by a single control valve, both brakes are actuated simultaneously. Also, the spring applied fluid released brake is always available for automatic emergency braking when fluid pressure is lost from the system. Furthermore, the spring applied fluid released brake may be independent of or an integral part of a service brake mechanism with the spring applied fluid release brake providing an emergency brake system to supplement the service brake system.

WHAT WE CLAIM IS:—

1. A vehicle brake system for stopping rotation of two independently rotatable elements, comprising a fluid pressure applied brake operatively associated with one of the rotatable elements; a spring applied, fluid pressure released brake operatively associated with the other of the rotatable elements, a pressurized fluid supply system connected to both brakes, and a valve system normally positioned to direct pressurized fluid to the spring applied, fluid pressure released brake whilst blocking fluid flow to the fluid pressure applied brake thus releasing both of the brakes permitting unrestricted rotation of the two elements, the valve system having a valve selectively positionable to cause fluid flow to the spring applied, fluid pressure released brake to be blocked and to cause pressurized fluid to be directed to the fluid pressure applied brake so that both of the brakes are applied for stopping rotation of the rotatable elements.

2. A brake system according to claim 1, wherein the valve system includes a manual control valve selectively positionable to block the supply of pressurized fluid to the spring applied, fluid pressure released brake, and a fluid actuated inversion valve positioned to direct the pressurized fluid to the fluid pressure applied brake in response to the blocking of the supply of pressurized fluid to the spring applied, fluid pressure released brake.

3. A brake system according to claim 2, wherein the fluid supply system includes a





hydraulic pump for supplying pressurized hydraulic fluid to the spring applied, fluid pressure released brake and a fluid actuated modulating valve positioned in response to pressurized fluid directed thereto from the manual control valve to direct the hydraulic fluid to the spring applied, fluid pressure released brake and positioned in response to the blocking of the pressurized fluid thereto from the manual control valve to block hydraulic fluid from the spring applied, fluid pressure released brake.

4. A brake system according to claim 2 or claim 3, wherein the fluid supply system includes a tank for compressed air and wherein the pressurized fluid directed through the manual control valve and the inversion valve is pressurized air.

5. A brake system according to claim 4, including a master cylinder having a fluid chamber, and actuator means for generating fluid pressure in the fluid chamber in response to pressurized air directed to the master cylinder, the supply system includes a conduit connecting the fluid chamber with the fluid pressure applied brake means.

6. A brake system according to any one of the preceding claims, including a second fluid pressure applied brake operatively associated with the other rotatable element, and means for directing pressurized fluid to the second brake for application thereof.

7. A brake system according to claim 6, wherein the fluid directing means includes a tank of compressed air, a master cylinder having a fluid chamber and actuator means for generating fluid pressure in the fluid chamber in response to pressurized air directed to the master cylinder, a fluid conduit connecting the fluid chamber to the second brake means, an air conduit connecting the tank with the master cylinder and valve means disposed in the air conduit for controlling the flow of pressurized air to the master cylinder.

8. A brake system according to claim 7, including a towing valve disposed in the fluid conduit having a position permitting fluid flow from the fluid chamber to the second fluid pressure applied brake, the towing valve being selectively positionable to direct pressurized fluid from the fluid chamber through the modulating valve to release the spring applied, fluid pressure released brake when the hydraulic pump is inoperative.

9. A brake system according to claims 3 and 4, or claim 5 or claim 6, when dependent upon claims 3 and 4, and wherein the modulating valve is air actuated and is arranged to block, in its normal position,

fluid flow to the spring applied, fluid pressure released brake, an air conduit connecting the compressed-air tank with the modulating valve, and a manual control valve disposed in the air conduit, being normally positioned to direct pressurized air through the air conduit to actuate the modulating valve to a position to direct pressurized fluid to the brake for releasing the brake, the manual control valve being selectively positionable modulatably to reduce air flow through the air conduit for shifting the modulating valve toward the normal fluid blocking position to modulatably reduce fluid flow to the brake for applying the brake for stopping rotation of the rotatable element.

10. A brake system according to claim 9, including a pair of master cylinders each having a fluid chamber and actuator means for generating fluid pressure in the fluid chamber in response to pressurized air directed to the master cylinder, a fluid conduit connecting the fluid chambers with the second fluid pressure applied brake, a check valve disposed in the conduit and operative to communicate pressurized fluid to the fluid applied brake from the fluid chamber which has the highest fluid pressure therein while blocking direct communication between the fluid chambers, a second air conduit connecting the tank with the master cylinders, a service valve means disposed in the second air conduit for controlling the flow of pressurized air from the tank to one of the master cylinders for controlling actuation of the second fluid pressure applied brakes, and retarder valve means disposed in the second air conduit in parallel with the service valve means for controlling the flow of pressurized air from the tank to the other of the master cylinders to provide a second method of actuating the fluid pressure applied brakes.

11. A brake system according to claim 10, wherein the rotatable elements are wheels of a vehicle, and including a control valve disposed in the fluid conduit and selectively positionable to connect the fluid conduit to the fluid chamber to provide a second source of pressurized fluid to release the spring applied, fluid pressure released brake to permit the vehicle to be towed when the pump is inoperative.

12. A brake system according to claim 1, substantially as described with reference to the accompanying drawing.

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