AU9514814

(12) PATENT ABRIDGMENT (11) Document No. AU-B-14814/95
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 668493

(54) Title
VEHICLE BRAKING FORCE DISTRIBUTION SYSTEM

International Patent Classification(s)
(51)[6] **B60T 008/30**

(21) Application No. : **14814/95** (22) Application Date : **14.03.95**

(30) Priority Data

(31) Number (32) Date (33) Country
6-43825 **15.03.94** **JP JAPAN**

(43) Publication Date : **07.12.95**

(44) Publication Date of Accepted Application : **02.05.96**

(71) Applicant(s)
TOYOTA JIDOSHA KABUSHIKI KAISHA

(72) Inventor(s)
NAOTO KUSHI; TATSUO SUGITANI; KIYOYUKI UCHIDA; KENJI ITO; TAKASHI KONDO; YOSHINORI KADOWAKI

(74) Attorney or Agent
SHELSTON WATERS , Level 21, 60 Margaret Street, SYDNEY NSW 2000

(56) Prior Art Documents
DE 4226646
AU 579420 50178/85 B60T 7/20 8/30 13/66
AU 576343 36753/84 B60T 8/18 8/26 F16K 17/30

(57) Claim

1. A braking system for braking a motor vehicle by operation of a front and a rear brake for a front and a rear wheel of the vehicle, respectively, characterized in that:

a distribution control device is provided to control a distribution of a front and a rear wheel braking force which are produced by said front and rear brakes, respectively, and which are applied to said front and rear wheels, said distribution control device controlling said distribution according to a selected one of a first distribution pattern and a second distribution pattern, each of said first and second distribution patterns representing said front and rear wheel braking forces with respect to each other such that said rear wheel braking force defined by said second distribution pattern is larger than that defined by said first distribution pattern at least when the front and rear wheel braking forces are smaller than respective predetermined values.

668493

AUSTRALIA

PATENTS ACT 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

Name of Applicant: TOYOTA JIDOSHA KABUSHIKI KAISHA

Actual Inventors: Naoto Kushi; Tatsuo Sugitani; Kiyoyuki Uchida; Kenji Ito; Takashi Kondo and Yoshinori Kadowaki

Address for Service: SHELSTON WATERS
60 Margaret Street
SYDNEY NSW 2000

Invention Title: "VEHICLE BRAKING SYSTEM DISTRIBUTION OF FRONT AND REAR BRAKING FORCES IS CONTROLLED ACCORDING TO TWO DIFFERENT DISTRIBUTION PATTERNS DEPENDING UPON VEHICLE LOAD"

The following statement is a full description of this invention, including the best method of performing it known to us:-

S 054031 140395

TITLE OF THE INVENTION

VEHICLE BRAKING SYSTEM DISTRIBUTION OF FRONT AND REAR BRAKING FORCES IS CONTROLLED ACCORDING TO TWO DIFFERENT DISTRIBUTION PATTERNS DEPENDING UPON VEHICLE LOAD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to a braking system, and more particularly to techniques for improving braking performance of a braking system of a motor vehicle by optimizing the distribution of braking forces of front and rear wheels of the vehicle.

Discussion of the Related Art

The braking forces of the front and rear wheels of a motor vehicle at which these front and rear wheels begin to be locked simultaneously on a road surface upon braking of the vehicle are represented by a curve which is upwardly convex as indicated in the graph of Fig. 1 wherein the braking force of the rear wheel is taken along the vertical axis while the braking force of the front wheel is taken along the horizontal axis. This curve is referred to as "ideal distribution curve", which represents an ideal distribution of the braking forces applied to the front and rear wheels. To improve the braking capacity or performance of the braking system, the specifications of the braking system should desirably be determined such that a curve of the actual distribution of the front and rear wheel braking forces is as close as possible to the ideal distribution curve. The specifications of the braking system include, for example, diameters of the front and rear wheel brake cylinders, effective radii of the front and rear disc brake rotors, and inside diameters of the front and rear wheel brake drums.

While the ideal distribution is represented by a curve as described above, the actual distribution of the front and rear wheel braking forces as established by a most basic arrangement of a braking system is represented by a straight line, as indicated in Fig. 1. The most basic arrangement is not provided with a load-sensing proportioning valve (LSP valve). It is also noted that the rear wheel braking force is not constant, but increases as the amount of load acting on the vehicle increases with respect to the minimum load, which is a load acting on the vehicle during a minimum-load run of the vehicle. The "minimum-load run" means a run of the vehicle with only the driver (without any passengers in the case of a passenger car, or without any cargo, luggage or load in the case of an industrial vehicle). The ideal distribution curves representing the ideal distributions during the minimum-load run of the vehicle differs from that during a full-load run of the vehicle, as also indicated in Fig. 1. The "full-load run" means a run of the vehicle with the nominal number of passengers (including the driver) in the case of the passenger car or the nominal maximum load in the case of the industrial vehicle.

Further, the braking system is generally designed so as to avoid locking of the rear wheels prior to locking of the front wheels upon braking of the vehicle, for the purpose of preventing the vehicle from losing control of the running direction. The braking system is also designed to prevent the prior locking of the rear wheels with respect to the front wheels during the minimum-load run in which the load acting on the rear wheels is the smallest, causing the rear wheels to having the highest locking tendency. Described in more detail, the braking system is usually adapted so as to minimize a deviation of the actual distribution of the front and rear wheel braking forces (i.e., a deviation of the basic distribution line as determined by the specifications of the most basic braking arrangement indicated above) from the ideal distribution curve, in a direction that causes an increase in the rear wheel braking force.

In practice, however, it is difficult to design the braking system so that the actual distribution line of the front and rear wheel braking forces is sufficiently close to the ideal distribution line. As shown in the graph of Fig. 1, the actual distribution line has a larger amount of deviation from the ideal distribution curve during the full-load run of the vehicle than during the minimum-load run. The deviation takes place in the direction that causes a decrease in the rear wheel braking force. That is, the designing of the braking system in an effort to accurately follow the ideal distribution curve has a limitation since the actual basic distribution is generally represented by a straight line and since the ideal distribution curve varies with a change in the vehicle load.

While the basic arrangement of the braking system has the drawback as described above, there is also known an improved arrangement in which a proportioning valve is disposed between the hydraulic pressure source and a rear wheel brake cylinder, so that the actual distribution line is made closer to the actual distribution curve. As indicated in Fig. 1, the actual distribution lines of the proportioning valve (load-sensing proportioning or LSP valve) are bent straight lines which are closer to the ideal distribution curve than the basic distribution lines. As disclosed in laid-open Publication No. 2-130870 (published in 1990) of unexamined Japanese Utility Model Application, the proportioning valve is a kind of pressure reducing valve which is adapted to reduce the hydraulic pressure generated by the hydraulic pressure source at a predetermined ratio and apply the reduced hydraulic pressure as the braking pressure to the rear wheel brake cylinder, after the generated hydraulic pressure has exceeded a predetermined threshold level. Until the generated hydraulic pressure reaches the threshold level (indicated by dots in Fig. 1 at the points of bending of the distribution lines of the proportioning valve), the proportioning valve does not function as the pressure reducing valve, and the hydraulic pressure as generated by the pressure source is applied to the rear wheel brake cylinder.

In industrial vehicles such as trucks in which the load acting on the rear wheels varies to a considerable extent with a varying amount of cargo, the braking capacity or performance cannot be sufficient when the load on the rear wheels is relatively large, if the threshold level indicated above is fixed, that is, if the level of the generated hydraulic pressure at which the proportioning valves begins to function as the pressure reducing valve is fixed. In view of this drawback, the braking system for such industrial vehicles is equipped with the proportioning valve of a load-sensing type also known in the art. In the load-sensing type proportioning valve (generally referred to as "LSP valve", or "LSPV"), the threshold level which corresponds to the point of bending of the distribution line of the valve changes with a change in the amount of load on the vehicle. There are two types of load-sensing proportioning valve, that is, a linkage type and a ball type. The linkage type utilizes a fact or phenomenon that the amount of relative displacement between portions of a sprung member and an unsprung member which portions correspond to the rear wheels of the vehicle increases with the load which acts on the rear wheels. Thus, the linkage type is adapted to detect the vehicle load in the form of the relative displacement amount of the sprung and unsprung members. The ball type utilizes a fact or phenomenon that the rear portion of the vehicle body is raised with respect to the front portion as the load on the rear wheels decreases. The ball type uses a ball adapted to roll on an inclined surface whose inclination angle changes with the inclination angle of the vehicle body, so that the ball is seated on a valve seat as a result of rolling. In the ball type, the difficulty of rolling of the ball on the inclined surface indicates the vehicle load.

However, the degree of approximation of the distribution line of the load-sensing proportioning valve to the ideal distribution curve is limited. That is, it has been difficult to sufficiently solve the undesirable tendency that the actual distribution line of the load-sensing proportioning valve deviates from the ideal distribution curve, in the direction that causes the rear wheel braking force to be smaller than the ideal value, particularly when the vehicle is in the full-load run, as is apparent from the graph of Fig. 1, wherein hatched area is an area of deviation of the actual rear wheel braking force from the ideal value. Therefore, during the full-load run of the vehicle, the actual braking forces applied to the rear wheels are considerably lower than the ideal value, or cannot be increased to the optimum value. Thus, the use of a load-sensing proportioning valve still suffers from insufficient braking forces of the rear wheels, although it prevents the locking of the rear wheels.

The above problem of difficulty of increasing the rear wheel braking forces to the ideal or optimum value during the full-load vehicle run is present also in an anti-lock braking system adapted to control the braking pressures of the wheels in an anti-lock fashion as well known in the art. The anti-lock control of the braking forces will be described in detail.

The braking system is classified into an independent front-rear braking force control type, and a diagonal or X-crossing type. In the independent front-rear braking force control type, a pressure application sub-system including the front right and left wheel brakes is independent of a pressure application sub-system including of the rear right and left wheel brakes. In the X-crossing type, a pressure application sub-system including the front left wheel brake and the rear right wheel brake is independent of a pressure application sub-system including the front right wheel brake and the rear left wheel brake.

In an anti-lock braking system of the independent front-rear braking force control type, the front wheel braking pressures and the rear wheel braking pressures are usually regulated independently of each other during an anti-lock control of the braking pressures. In this case, the actual front-rear distribution of the braking forces is not bound by the basic distribution line determined by the specifications of the braking system, but can be changed with a high degree of freedom from the basic distribution line. Accordingly, the actual distribution line can be made sufficiently close to the ideal distribution curve. Therefore, the braking system of the independent front-rear braking force control type does not suffer from the above problem that the rear braking forces cannot be increased sufficiently during the full-load run of the vehicle.

In an anti-lock braking system of the X-crossing type, several arrangements are available for effecting the anti-lock control of the braking forces. One example of such arrangements is illustrated in Fig. 2, wherein a normally-open master cylinder cut-off valve 306 is provided in a front brake cylinder passage 304 connecting a master cylinder 300 (hydraulic pressure source) and a front wheel brake cylinder 302, while a rear brake cylinder passage 308 is connected at one end thereto to a portion of the front brake cylinder passage 304 between the cut-off valve 306 and the front wheel brake cylinder 302. The rear brake cylinder passage is connected at the other end to a rear wheel brake cylinder 307. A normally-closed shut-off valve in the form of a pressure reducing valve 312 is provided in a reservoir passage 310 which is connected at one end thereto to the rear brake cylinder passage 308 and at the other end to a reservoir 316, which receives the brake fluid discharged from the wheel brake cylinders 302, 307 through the shut-off valve 312. A pump 318 is connected to the reservoir 316 to return the brake fluid to the master cylinder 300. According to this braking arrangement, the braking pressures in the front and rear wheel brake cylinders 302, 307 are increased by the pressure generated by the master cylinder 300.

The assignee of the present application proposed another braking arrangement of the X-crossing type, as shown in Fig. 3. Unlike the braking arrangement of Fig. 2, the present braking arrangement of Fig. 3 is adapted to increase the braking pressures in the the front and rear wheel brake cylinders by operation of the pump 318. That is, the master cylinder cut-off valve 306 is held closed during an anti-lock control of the braking pressures, in principle, and the pump 318 is connected to a portion of the front brake cylinder passage 304 which is downstream of the cut-off valve 306, so that the pressurized fluid from the pump 318 is not returned to the master cylinder 300 but is returned to the wheel brake cylinders 302, 307, whereby the braking pressures in the wheel brake cylinders are increased by operation of the pump 318 during the anti-lock control of the braking system.

In either of the two arrangements of the anti-lock braking system of the X-crossing type, the braking pressures in the front and rear wheel brake cylinders 302, 307 cannot be regulated independently of each other, but are regulated such that the braking pressure in the front wheel brake cylinder 302 is equal to that in the rear wheel brake cylinder 307. Therefore, unlike the braking system of the independent front-rear braking force control type, the braking system of the X-crossing type is not capable of establishing the actual distribution line which is shifted from the basic distribution line in the direction that causes an increase in the braking pressure in the rear wheel brake cylinder during the anti-lock control. Thus, like the ordinary braking system incapable of effecting the anti-lock control of the braking forces, the braking system of the X-crossing type suffers from the problem of insufficient braking forces of the rear wheels during the full-load run of the vehicle.

The anti-lock braking system of the X-crossing type may take further arrangements as illustrated in Figs. 4 and 5. In the arrangement of Fig. 4, two 3-position valves 320 each having a pressure-increase position, a pressure-hold position and a pressure-decrease position are provided for the front and rear wheel brake cylinders 302, 307, respectively. In the arrangement of Fig. 5, a series connection of two shut-off valves 322, 324 is provided for each of the front and rear wheel brake cylinders 302, 307, in place of the 3-position valve 320 used in the arrangement of Fig. 4. Although these arrangements of Figs. 4 and 5 permit the actual distribution of the front and rear wheel braking forces to be controlled without restriction by the basic distribution line, these arrangements have another problem that the construction is inevitably complicated, leading to an increased cost of manufacture.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome or ameliorate at least some of these deficiencies of the prior art.

According to the invention there is provided a braking system for braking a motor vehicle by operation of a front and a rear brake for a front and a rear wheel of the vehicle, respectively, characterized in that:

a distribution control device is provided to control a distribution of a front and a rear wheel braking force which are produced by said front and rear brakes, respectively, and which are applied to said front and rear wheels, said distribution control device controlling said distribution according to a selected one of a first distribution pattern and a second distribution pattern, each of said first and second distribution patterns representing said front and rear wheel braking forces with respect to each other such that said rear wheel braking force defined by said second distribution pattern is larger than that defined by said first distribution pattern at least when the front and rear wheel braking forces are smaller than respective predetermined values.

An advantage of this invention is it provides an anti-lock braking system wherein the duty cycle of the intermediate valve can be changed to thereby further improve the freedom of control of the braking pressures.

A further advantage of the invention is it provides an anti-lock braking system wherein the duty cycle of the intermediate valve can be optimally controlled on the basis of the pressure reducing tendencies during the anti-lock pressure control operation.

According to the present invention, there is provided a braking system as schematically illustrated in Fig. 6, for braking a motor vehicle by operation of a front brake 202 and a rear brake 204 for respective front and rear wheels of the vehicle, the braking system including a distribution control device 210 adapted to control a distribution of a front and a rear wheel braking force which are produced by the front and rear brakes 202, 204, respectively, and which are applied to the front and rear wheels. The distribution control device 210 controls the distribution according to a selected one of a first distribution pattern and a second distribution pattern. Each of the first and second distribution patterns represents the front and rear wheel braking forces with respect to each other such that the rear wheel braking force defined by the second distribution pattern is larger than that defined by the first distribution pattern at least when the front and rear wheel braking forces are smaller than respective predetermined values. Namely, the first and second distribution patterns are formulated so that the rear wheel braking force according to the second distribution pattern is smaller than that according to the first distribution pattern, at least when the vehicle is braked with the relatively small braking forces applied to the front and rear wheels.

The present braking system may of course use friction brakes as the front and rear brakes, but may use other types of brakes such as electromagnetic brakes, rheostatic brakes, electro-regenerative brakes and pneumatic brakes.

The distribution control device 210 used in the present braking system may take various forms. In the braking system equipped with hydraulically operated friction brakes, for example, the front and rear braking forces may be controlled by regulating the hydraulic braking pressures (pressures of the brake fluid) applied to the friction brakes, or by controlling pressure-receiving areas of pistons which receive the hydraulic braking pressures to force friction members onto rotors rotating with the vehicle wheels. In the latter case, the number of the pistons which are effectively operated for each of the rotors may be suitably selected.