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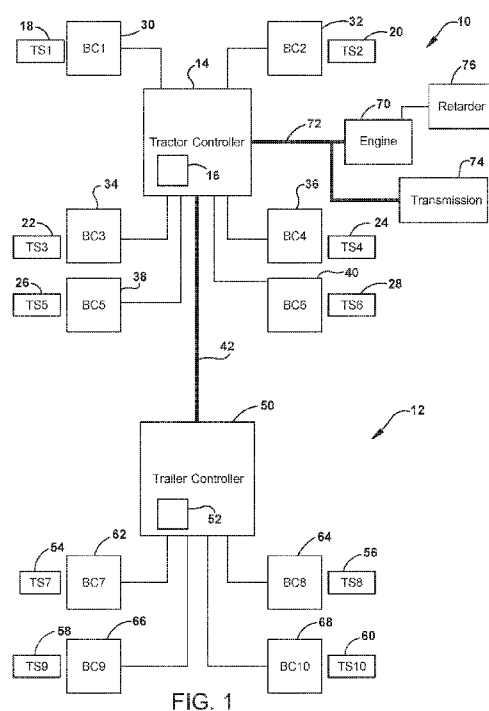


FIG. 1

(57) Abstract: A method for modifying a brake application of a combination vehicle comprises receiving a temperature signal of a first brake pad of a first brake assembly and receiving a temperature signal representative of a temperature of a second brake pad of a second brake assembly. The temperatures are compared to a first predetermined temperature. The method will determine if service brakes of the trailer are being applied by a driver and compare a wheel speed of the trailer with the wheel speed of a tractor of the combination vehicle. The method will determine a brake drag exists on the trailer in response to both the first and the second brake pad temperature being greater than the first predetermined temperature, the trailer wheel speed being less than the tractor wheel speed and the service brakes not being applied by the driver.

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
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METHOD FOR USING BRAKE PAD INFORMATION IN BRAKING APPLICATIONS

Background

[0001] The present invention relates to embodiments of an apparatus and method for using brake pad temperature information to modify braking applications. Commercial vehicle brake friction material reaches different temperatures depending on the route driven, the terrain of the route, the condition of the braking assembly and the brake application frequency. The state of the friction material affects the braking ability of the commercial vehicle. Therefore, there is a need for a method to use brake pad temperature information to improve brake application and lengthen brake pad useful life in commercial vehicles.

Summary

[0002] Various embodiments of a system for determining a brake application based on brake pad temperature information are disclosed. The system comprises a first brake pad temperature sensor for transmitting temperature signals, the first brake pad temperature sensor measuring a temperature of a brake pad associated with a first wheel end; a second brake pad temperature sensor for transmitting temperature signals, the second brake pad temperature sensor measuring a temperature of a brake pad associated with a second wheel end; a first brake control device associated with the first wheel end; a second brake control device associated with the second wheel end; and a controller for receiving the temperature signals and transmitting a brake control signal, wherein the brake control signal is modified based on the temperature signals.

[0003] Various methods for modifying a brake application on a trailer of a combination vehicle are disclosed. One method for modifying a brake application on a trailer of a combination vehicle comprises receiving a temperature signal representative of a temperature value of a first brake pad associated with a first brake assembly on a first axle of a trailer and receiving a temperature signal representative of a temperature value of a second

brake pad associated with a second brake assembly on the first axle of the trailer. The method includes comparing the first and second brake pad temperature values to a predetermined first temperature threshold, then determining if service brakes of the trailer are being applied by a driver. The method includes comparing a wheel speed of the trailer with the wheel speed of a tractor of the combination vehicle. The method includes determining a brake drag exists on the trailer in response to both the first and the second brake pad temperature being greater than the first temperature threshold, the trailer wheel speed being less than the tractor wheel speed and the service brakes not being applied by the driver. The method includes transmitting an alert signal to alert the driver to the presence of brake drag.

[0004] Another method for modifying a brake application comprises receiving a temperature signal indicating a temperature value of at least one brake pad associated with at least one brake assembly. The method includes comparing the temperature of one of the at least one brake pad to a predetermined first temperature value and determining the at least one brake assembly is locked in response to the brake pad temperature being above the first temperature threshold while the other of the at least one brake pad temperature signals remain lower than the first temperature threshold.

Brief Description of the Drawings

[0005] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0006] **FIGURE 1** illustrates a commercial vehicle equipped with the braking systems and brake pad temperature measurement systems of the present invention.

[0007] **FIGURE 2** illustrates a method of determining brake drag according to one example of the present invention.

[0008] **FIGURE 3** illustrates a method of determining and responding to a potential glazed brake pad or brake fade when a braking event is requested.

[0009] **FIGURE 4** illustrates a method of balancing brake temperature, according to one example of the present invention.

Detailed Description

[0010] **FIGURE 1** illustrates a tractor brake system **10** of a commercial vehicle having a brake pad temperature analysis system according to one example of the present invention. Figure 1 also illustrates a trailer brake system **12** of the commercial vehicle having a brake pad temperature analysis system.

[0011] The tractor system **10** includes a tractor controller **14**. The tractor controller **14** includes a processor with control logic **16** for receiving and transmitting signals. The control logic **16** may include volatile, non-volatile memory, solid state memory, flash memory, random-access memory (RAM), read-only memory (ROM), electronic erasable programmable read-only memory (EEPROM), variants of the foregoing memory types, combinations thereof, and/or any other type(s) of memory suitable for providing the described functionality and/or storing computer-executable instructions for execution by the control logic **16**.

[0012] The tractor controller **14** receives signals from various temperature sensors on the tractor. For example, temperature sensors **18 (TS1)**, **20 (TS2)**, **22 (TS3)**, **24 (TS4)**, **26 (TS5)**, **28 (TS6)** are located proximate to a brake assembly, internal to a braking component or within the brake pad for each wheel end on the tractor. The temperature sensors **TS1-TS6** may transmit temperature information through wires to the tractor controller **14** or may transmit wirelessly. The temperature sensors **TS1-TS6** may be thermocouples, thermistors, camera based thermal imaging or other means of collecting temperature information from in and around a brake pad. The control logic **16** receives the temperature sensor information.

[0013] The tractor controller **14** transmits brake control signals to brake control devices **30 (BC1)**, **32 (BC2)**, **34 (BC3)**, **36 (BC4)**, **38 (BC5)**, **40 (BC6)** to control the braking of the tractor. **BC1-BC6** may receive the brake control signals through wires or wirelessly. Braking begins with either a driver requested braking event or through an automated braking request received by the braking controller **14**. The braking action may be modified by the control logic **16** based on the temperature sensor information from TS1-TS6.

[0014] The tractor controller **14** communicates with an engine controller **70** via a vehicle serial communications bus **72**. The engine controller **70** may control a retarder function and/or engine braking. Alternatively, the tractor controller **14** may communicate directly with a retarder **76** via the communications bus **72**. The retarder **76** assists in slowing the vehicle by changing the engine operation in response to deceleration messages. The tractor controller **14** also communicates with a transmission controller **74** via the vehicle serial communications bus **72**. The transmission controller **74** controls the shifting of the automatic or semi-automatic transmission.

[0015] The tractor controller **14** communicates with a trailer controller **50** via a tractor-trailer communications line **42**. The communications line **42** may use SAE J1939, SAE J2497 PLC or LIN protocols. Alternatively, the tractor controller **14** and trailer controller **50** may communicate wirelessly. Digital wireless communication protocols may include WiFi, Bluetooth and Near Field Communications.

[0016] The trailer controller **50** of trailer braking system **12** includes a processor with control logic **52** for receiving and transmitting signals. The control logic **52** may include volatile, non-volatile memory, solid state memory, flash memory, random-access memory (RAM), read-only memory (ROM), electronic erasable programmable read-only memory (EEPROM), variants of the foregoing memory types, combinations thereof, and/or any other type(s) of memory suitable for providing the described functionality and/or storing computer-executable instructions for execution by the control logic **52**.

[0017] The trailer controller **50** receives signals from various temperature sensors on the trailer. For example, temperature sensors **54 (TS7)**, **56 (TS8)**, **58 (TS9)**, **60 (TS10)** are located proximate to a brake assembly, internal to a braking component or within the brake

pad for each wheel end on the trailer. The temperature sensors **TS7-TS10** may transmit temperature information through wires to the trailer controller **50** or may transmit wirelessly. The temperature sensors **TS7-TS10** may be thermocouples, thermistors, camera based thermal imaging or other means of collecting temperature information from in and around a brake pad. In trailers with multiple axles or applications with multiple trailers, additional temperatures sensors may be installed. The control logic **52** receives the temperature sensor information from **TS7-TS10**.

[0018] The trailer controller **50** transmits brake control signals to brake control devices **62 (BC7)**, **64 (BC8)**, **66 (BC9)**, **68 (BC10)** to control braking of the trailer. **BC7-BC10** may receive brake control signals through wires or wirelessly. Braking begins with either a driver requested braking event as transmitted pneumatically or electrically to the trailer braking system **12** or by an automated braking request received by the trailer controller **50** via the communications line **42**. The braking action may be modified by the control logic **52** based on the temperature sensor information.

[0019] Therefore, a system for determining a brake application comprises a first brake pad temperature sensor for transmitting temperature signals, the first brake pad temperature sensor measuring a temperature of a brake pad associated with a first wheel end; a second brake pad temperature sensor for transmitting temperature signals, the second brake pad temperature sensor measuring a temperature of a brake pad associated with a second wheel end; a first brake control device associated with the first wheel end; a second brake control device associated with the second wheel end; and a controller for receiving the temperature signals and transmitting a brake control signal, wherein the brake control signal is modified based on the temperature signals.

[0020] **FIGURE 2** illustrates a method for determining brake drag on a trailer using the temperature sensor information, according to one example of the invention. The method **100** begins with receiving the temperature from all of the temperature sensors **TS7-TS10** of the trailer braking system **12** in step **102**. For this example, the temperature values from temperature sensors **TS7-TS10** of the trailer are part of the temperature signals received by the trailer controller **50**. The trailer control logic **52** compares the signal of each of the

temperature sensors **TS7-TS10** to a predetermined first temperature threshold T1 in step **104**. If all of the temperature values received are less than the first temperature threshold T1, the method **100** returns to step **102** to continue to receive the temperature signals from each of the temperature sensors.

[0021] If any or all of the temperature signals from **TS7-TS10** are equal to or greater than the first temperature threshold T1, the method **100** proceeds to step **106**. In one example, the first temperature threshold T1 is initially set at about 400 degrees Fahrenheit. This 400F value is selected as a temperature value that is above what is considered a normal operating temperature for a commercial vehicle brake pad. In an example drum brake assembly, a predetermined second temperature threshold T2 may be set at a value where brake fade has been determined to begin. Fading occurs when the brake drum has expanded such that the friction material may no longer be engaging the brake drum. T2 may be set at about 600F. In an example disc brake assembly, a predetermined third temperature threshold T3 may be set at a value at which glazing of the brake pad may begin. The third temperature threshold T3 may be set at about 1100F. Glazing is caused when the brake pad friction material is overheated. Glazing results in crystallized friction material on the pad surface and the brake disc. Typical symptoms of glazed brake pads or brake fade include poor stopping performance, vibration or brake shudder, and cracks or fissures in the brake pad material. The method **100** may alert the driver to these potential conditions through an audible or visual means. The method **100** attempts to avoid the effects of brake pads being held at or above these temperatures for long periods of time, as will be explained.

[0022] In step **106**, the trailer control logic **52** determines if the trailer has moved. The trailer control logic **52** may determine movement from the reading of wheel speed sensors or other technology on the trailer. If the trailer has not moved, as determined by the wheel speed sensors generating zero speed for example, then the trailer control logic **52** attempts to release the parking brakes on the trailer in step **108**. In some situations, the parking brakes may have failed to have been released by the driver before trying to move the trailer. Dragging parking brakes can cause the temperature sensors **TS7-TS10** to capture

elevated readings. Once the parking brakes are released, the temperature data is received again by control logic **52** in step **110** to determine if the temperature is decreasing.

[0023] If the trailer had moved in step **106** based on the wheel speed sensors reading greater than zero speed for example, the method **100** proceeds directly to step **110**.

[0024] The method **100** then determines in step **110** if the temperature values received from sensors **TS7-TS10** are decreasing from the previously measured values. If the temperature of all the sensors **TS7-TS10** is decreasing, the method **100** moves to step **114** to wait for the next brake event.

[0025] If the brake temperature sensors **TS7-TS10** are instead increasing, the method **100** moves to step **112** to determine if the service brakes are being applied. If the service brakes are being applied, either manually by the driver or autonomously as determined by the trailer controller **50**, a separate brake event algorithm, as shown as method **200** in Figure 3, is initiated.

[0026] If the trailer control logic **52** determines that the service brakes are not being applied, the method **100** moves to step **116**.

[0027] In step **116**, the wheel speed of the trailer axle is compared to the wheel speed of the tractor axle(s). The trailer controller **50** receives the tractor wheel speed information from the tractor controller **14** via the communications line **42**. If the wheel speed is relatively the same between the tractor and the trailer, then the method **100** proceeds to step **114** to continue to wait for the next brake event. If the wheel speed between the tractor axle(s) and trailer axle is different, for example a difference of greater than about 10%, then the method **100** proceeds to step **118**.

[0028] If all of the **TS7-TS10** brake pad temperatures are increasing and the wheel speeds are different between the tractor and the trailer, brake drag at the trailer is identified. If only a single brake pad temperature, such as **TS7**, or two brake pad temperatures on the same axle, such as **TS7** and **TS8** are increasing, as determined in step **110**, a locked axle or brake is identified.

[0029] In step **119**, the parking brake is again attempted to be released through electronic control. Also in step **119**, the individual trailer service brake associated with the

temperature sensor having the highest temperature value is attempted to be released through means such as increasing pressure at that wheel end or a brief brake apply. In one example, brake controller **BC7** may be cycled to ensure that no air is trapped in the brake actuator. In step **120**, the method **100** determines whether the brake was successfully released. If the trailer brake associated with the higher temperature brake pad is successfully released, meaning the wheel speed increase matches speed at other wheel ends, or the temperature at the identified wheel end decreases in temperature, then the method **100** proceeds to step **114** to wait for the next brake event.

[0030] If the trailer brake drag or locked wheel continues because the trailer brake(s) cannot be released, then the method **100** proceeds to step **122** where the driver is alerted and a brake drag event or locked wheel flag is set. In some instances, the trailer controller **50** may set itself in a limp home mode, which will limit some functionality of the vehicle due to the locked wheel or brake drag event. For example, the trailer controller **50** may transmit a message to the tractor controller **14** to request a throttle limit message be sent to the engine controller **70** so as to limit the maximum speed of the vehicle when in the limp home mode. The ABS warning light in the tractor may be illuminated. An audible warning may also be given to the driver. A message may be displayed on a driver information unit regarding the trailer brake drag.

[0031] In step **124**, the temperature threshold for enabling retarder braking is lowered. For example, the first temperature threshold T1 at which retarder action may begin may originally have been set at 400F. The first temperature threshold T1 may be reduced to 350F, for example. In other words, the trailer controller **50** will request the retarder to contribute to the braking of the vehicle when the measured temperature from any one of **TS7-TS10** is at a lower temperature than what was originally predetermined as T1 when the method **100** began. The control logic **52** will send a message to the tractor controller **14**, which will relay the message to engine controller **70** to activate the retarder accordingly.

[0032] In step **126**, the brake efficiency and performance tables will be updated with the information indicating the location of the locked wheel or dragging brake. For example, additional pressure may be applied to meet stopping distance requirements for the hotter

wheel end. The updated brake efficiency and performance tables will be used to support future braking actions.

[0033] Therefore, a method for modifying a brake application on a trailer of a combination vehicle comprises receiving a temperature signal representative of a temperature of a first brake pad associated with a first brake assembly on a first axle of a trailer; receiving a temperature signal representative of a temperature of a second brake pad associated with a second brake assembly on the first axle of the trailer; comparing the first and second brake pad temperatures to a first predetermined temperature; determining if service brakes of the trailer are being applied by a driver; comparing a wheel speed of the trailer with the wheel speed of a tractor of the combination vehicle; determining a brake drag exists on the trailer in response to both the first and the second brake pad temperature being greater than the first predetermined temperature, the trailer wheel speed being less than the tractor wheel speed and the service brakes not being applied by the driver; and transmitting an alert signal to alert the driver to the presence of brake drag.

[0034] **FIGURE 3** illustrates the brake event method **200** of determining and responding to a potential glazed brake pad or brake fade on a tractor or trailer of a combination vehicle when a brake event is requested. A braking event request begins in step **202**. The braking request may be from an automated braking system or from a driver. The desired deceleration is determined from the force applied by the driver on the brake pedal or from the electronic system requesting the braking event. In step **206**, the input signals from the temperature sensors **TS7-TS10** of the trailer brake system **12** are received. In step **208**, the control logic **52** compares the temperatures values received to a look up table stored in the control logic **52**.

[0035] The look up table for a drum brake equipped air brake system may be as shown in Table 1.

[0036] **TABLE 1**

Temperature of any one brake pad	Braking Response
Ambient to $\frac{1}{2}$ value of T1	Normal

$\frac{1}{2}$ value of T1 to T1	Normal – monitor temperature sensors more frequently
T1 to T2	Increase retarder assistance to support service braking
Above T2	Fading of this wheel end brake assembly is likely begun. Identify the brake assembly as having reduced performance. Begin to increase braking at other wheel ends.

[0037] The look up table for a disc brake equipped air brake system may be as shown in Table 2.

[0038] **TABLE 2**

Temperature of any one brake pad	Braking Response
Ambient to $\frac{1}{2}$ T1	Normal
$\frac{1}{2}$ T1 to T1	Normal – monitor temperature sensors more frequently
T1 to T3	Increase retarder assistance to support service braking
Above T3	Glazing of brake pad at this wheel end is likely. Begin to increase braking at other wheel ends. Identify the brake assembly as having reduced performance.

[0039] If the temperature values received from **TS7-TS10** are about half the value of the first temperature threshold T1, the no changes are made. If the temperature values are between about half the value of the first temperature threshold T1 and T1, then the temperature sensors **TS7-TS10** may be monitored more frequently as the rising temperature

may be indicative of a future problem. If the temperature values remain below T1, then the method **200** moves to step **212**. The control logic **52** applies the brakes according to look up table in step **212**. If brakes are still being requested as in step **214**, then the method **200** returns to step **204**. If braking is no longer requested, then the method **200** ends the braking at step **216**.

[0040] In one example, on a brake that is already determined to have reached T3, the retarder may be actuated when that particular brake reaches a temperature a factor lower than T1, since the state of that brake has already been recorded as “potentially glazed.” In order to support the glazed brake, the other brakes in the system may be allowed to reach a temperature a factor above T1 before the retarder is actuated. The status of a brake as “potentially glazed” remains with that brake until the control logic **52** is reset after a brake change. If brakes are still being requested as in step **214**, then the method **200** returns to step **204**. If braking is no longer requested, then the method **200** ends the braking at step **216**.

[0041] If the braking required to achieve deceleration determine in step **204** is determined to possibly cause glazing of the brakes due to the temperature values from **TS7-TS10** nearing, but not exceeding, the third temperature threshold T3 or fading of the brakes due to nearing the second temperature threshold as determined in step **210**, the method **200** proceeds to step **218**. In step **218**, the trailer control logic **52** determines if the deceleration request can be accomplished via a transmission downshift or via application of the engine retarder. If the deceleration request cannot be accomplished in this manner, the brakes are still applied based on the lookup table as in step **220**. In step **222**, the brake pad temperature from **TS7-TS10** is analyzed again. In step **224**, each brake pad temperature value is compared with a predetermined temperature value according to Table 1 or Table 2.

[0042] If the second temperature threshold T2 or third temperature threshold T3 has been reached as determined in step **224**, the method **200** proceeds to step **230** to update lookup table to indicate that particular wheel end brake pad is glazed or faded. For example, if **TS7** is installed on an air disc brake assembly. If the temperature value of **TS7** sensor exceeds 1100F, then the brake pad associated with **TS7** is determined to likely be glazed. In response, the trailer controller **50** may begin in the modified braking setup in step **228**. The

braking may be modified by applying greater pressure at different wheel ends to achieve higher braking efficiency. For example, if the wheel end brake assembly associated with **TS8** has never reached the third temperature threshold **T3**, the trailer controller **50** will send a brake signal to **BC8** for a normal brake apply when a brake activation is requested.

However, since the brake pad associated with **TC7** has been determined to likely be glazed, then the trailer controller **50** may set this brake assembly as only 82% efficient. In this manner, the trailer controller **50** will transmit brake control signals to apply more brake pressure to that wheel end via **BC7** to improve the brake efficiency. This 82% efficiency value will be assigned to the brake assembly associated with **TC7** and be used in future braking calculations.

[0043] The method **200** continues to step **214** to determine if braking is still being requested. If braking is being requested the method **200** goes back to step **204** and uses the updated look up tables. If braking is no longer being requested, the method **200** ends the braking in step **216**.

[0044] If the second temperature threshold **T2** or third threshold temperature **T3** has not been reached in step **224**, the lookup table is not modified. Braking will be done according to the existing table in step **228**. The method **200** continues to step **214** to determine if braking is still being requested. If braking is being requested the method goes back to step **204** and uses the updated look up tables. If braking is no longer being requested, the method **200** ends the braking in step **216**.

[0045] If, in step **218**, the control logic **52** determines that the deceleration can be accomplished or supplemented by the transmission downshift or activation of the retarder, the method **200** proceeds to step **232**. In step **232**, the deceleration is equivocated to a transmission downshift and retarder activation. The trailer controller **50** will send a message to the tractor controller **14** via the communications line **42**. In step **228**, the tractor controller **14** will respond by transmitting a message to the engine controller **70** to actuate the retarder and/or transmitting a message to the transmission controller **74** to downshift. In step **234**, the driver will be alerted to the assistive deceleration of the retarder or transmission.

[0046] However, the service brakes may still need to be applied in step **236** to achieve the desired deceleration, but at a rate that may not cause additional fading or glazing, or fading or glazing of other brake assemblies. The method **200** continues to step **224** to determine if glazing or fading has occurred.

[0047] If the second temperature threshold T2 or the third temperature threshold T3 has been reached, the method **200** proceeds to step **230** to update lookup table to indicate that particular wheel end brake pad associated with the temperature value is glazed or faded. In response, the braking may begin in the modified braking setup in step **228** according to the new look up table. The method **200** continues to step **214** to determine if braking is still being requested. If braking is being requested, the method **200** returns to step **204** and uses the updated look up tables. If braking is no longer being requested, the method **200** ends the braking in step **216**.

[0048] If the second temperature threshold T2 or third temperature threshold T3 has not been reached in step **224**, braking will be achieved according to the new table in step **228**. The method **200** continues to step **214** to determine if braking is still being requested. If braking is being requested, the method **200** goes back to step **204** and uses the updated look up tables. If braking is no longer being requested, the method **200** ends the braking in step **216**.

[0049] **FIGURE 4** illustrates a method **300** of balancing brake temperature. In step **302**, the method **300** determines a locked brake or brakes exist. In step **304**, the trailer controller **50** will transmit a brake control signal to the brake control device associated with the locked brake. The brake control signal will pulse the brakes at the wheel end in an attempt to loosen the brake assembly from the locked state.

[0050] In step **306**, the trailer controller **50** allows an increase in brake temperature above the first temperature threshold T1 at the other non-locked brakes to help alleviate the locked brake(s) situation. In step **308**, the temperatures of the remaining brakes are monitored to determine if they are increasing. If the temperatures are not increasing, the method **300** proceeds to method **200** as in Figure 3. If the temperature continues to increase, the method **300** proceeds to step **310** to cause the retarder to contribute to deceleration.

Alternatively, the trailer controller **50** will actuate other brakes further away from locked brake assembly. In step **312**, the driver is alerted to possible glazing or fading of the brakes. In step **314**, the brake efficiency and performance lookup table data is updated with the new information. In this manner, the trailer controller **50** keeps track of which brake has reached the second temperature threshold T2 that may have caused brake fade or reached the third temperature threshold T3 that may have caused brake glazing. The monitoring of the brake pad temperature continues as the method **300** returns to step **302**.

[0051] Each of the methods **200** and **300** may be applied to the tractor braking system **10** as well as the trailer braking system **12**.

[0052] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

We claim:

1. A method for modifying a brake application on a trailer of a combination vehicle comprising:

receiving a temperature signal representative of a temperature value of a first brake pad associated with a first brake assembly on a first axle of a trailer;

receiving a temperature signal representative of a temperature value of a second brake pad associated with a second brake assembly on the first axle of the trailer;

comparing the first and second brake pad temperature values to a predetermined first temperature threshold;

determining if service brakes of the trailer are being applied by a driver;

comparing a wheel speed of the trailer with the wheel speed of a tractor of the combination vehicle;

determining a brake drag exists on the trailer in response to both the first and the second brake pad temperature values being greater than the first temperature threshold, the trailer wheel speed being less than the tractor wheel speed and the service brakes not being applied by the driver; and

transmitting an alert signal to alert the driver to the presence of brake drag.

2. The method as in claim 1 further comprising:

transmitting a signal to release the parking brakes on the trailer; and

determining brake drag is still present in response to both the first and the second brake pad temperature values remaining greater than the first temperature threshold and the trailer wheel speed remaining less than the tractor wheel speed.

3. The method as in claim 1, further comprising: transmitting a signal to the engine to limit the throttle.

4. The method as in claim 1, wherein the predetermined first temperature threshold is about 400F.

5. The method as in claim 1, wherein the first brake pad is one of an disc brake pad and a drum brake pad for a pneumatic braking system.

6. A method for modifying a brake application comprising:

receiving a temperature signal indicating a temperature value of at least one brake pad associated with at least one brake assembly;

comparing the temperature value of one of the at least one brake pad to a predetermined first temperature threshold; and

determining the at least one brake assembly is locked in response to the brake pad temperature value being above the first temperature threshold while the other of the at least one brake pad temperature signals remain lower than the first temperature threshold.

7. The method as in claim 6, further comprising increasing the value of the first temperature threshold, wherein an other of the at least one brake pads reaches the increased first temperature threshold prior to activation of the retarder to decelerate the vehicle.

8. The method as in claim 6, wherein the at least one brake pad is on a tractor brake assembly or a trailer brake assembly.

9. The method as in claim 6, further comprising activating a retarder on a tractor of the combination vehicle to assist the service brakes in slowing the combination vehicle.

10. The method as in claim 9, further comprising:

lowering the predetermined first temperature threshold; and

activating the retarder to support braking of the combination vehicle when the at least one brake pad temperature value exceeds the lowered first temperature threshold.

11. The method as in claim 6, further comprising comparing the temperature value of the at least one brake pad to a predetermined second temperature threshold and changing the brake control signal to a brake control device associated with the at least one brake pad to increase pressure delivered to the brake assembly in response to the at least one brake pad temperature value exceeding the second temperature threshold.

12. The method as in claim 11, wherein the predetermined second temperature threshold is about 600F.

13. The method as in claim 11, further comprising updating a lookup table such that the brake control device associated with the at least one brake pad will receive higher brake

pressure via brake control device than other brake control devices in response to the at least one brake pad temperature value exceeding the second temperature threshold.

14. The method as in claim 6, further comprising comparing the temperature value of the at least one brake pad to a predetermined third temperature threshold and updating a lookup table so that the brake assembly associated with the at least one brake pad receives higher pressure than other brake controllers on vehicle in response to the temperature value exceeding the third temperature threshold.

15. The method as in claim 14, wherein the third predetermined temperatures is about 1100F.

16. A system for determining a brake application comprising:

- a first brake pad temperature sensor for transmitting temperature signals, the first brake pad temperature sensor measuring a temperature of a brake pad associated with a first wheel end;

- a second brake pad temperature sensor for transmitting temperature signals, the second brake pad temperature sensor measuring a temperature of a brake pad associated with a second wheel end;

- a first brake control device associated with the first wheel end;

- a second brake control device associated with the second wheel end; and

- a controller for receiving the temperature signals and transmitting a brake control signal, wherein the brake control signal is modified based on the temperature signals.

17. The system as in claim 16, further comprising a retarder, wherein the controller transmits a retarder actuation signal to actuate the retarder in addition to the brake control device in response to the temperature signals being between a predetermined first temperature value and a predetermined second temperature value.

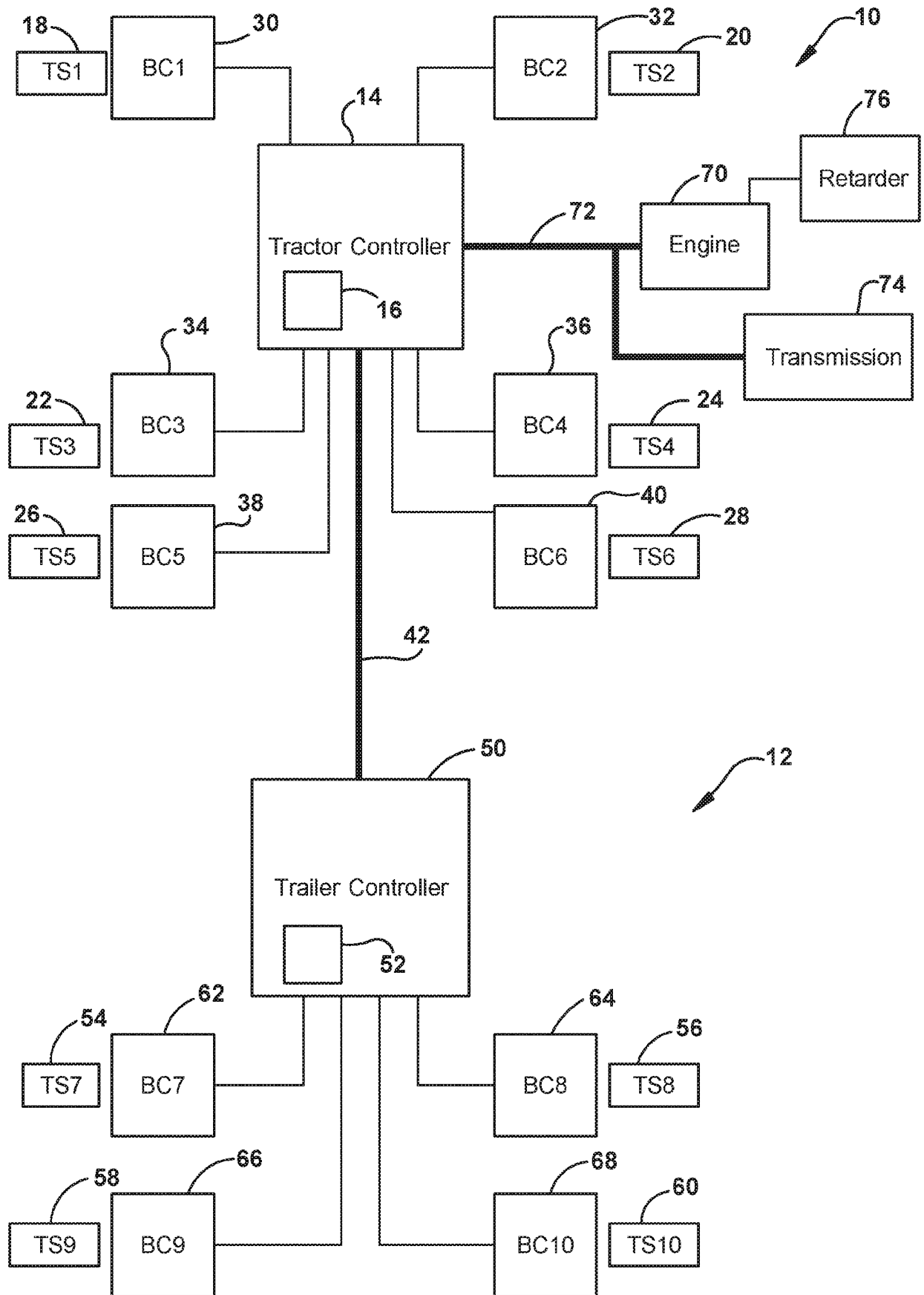
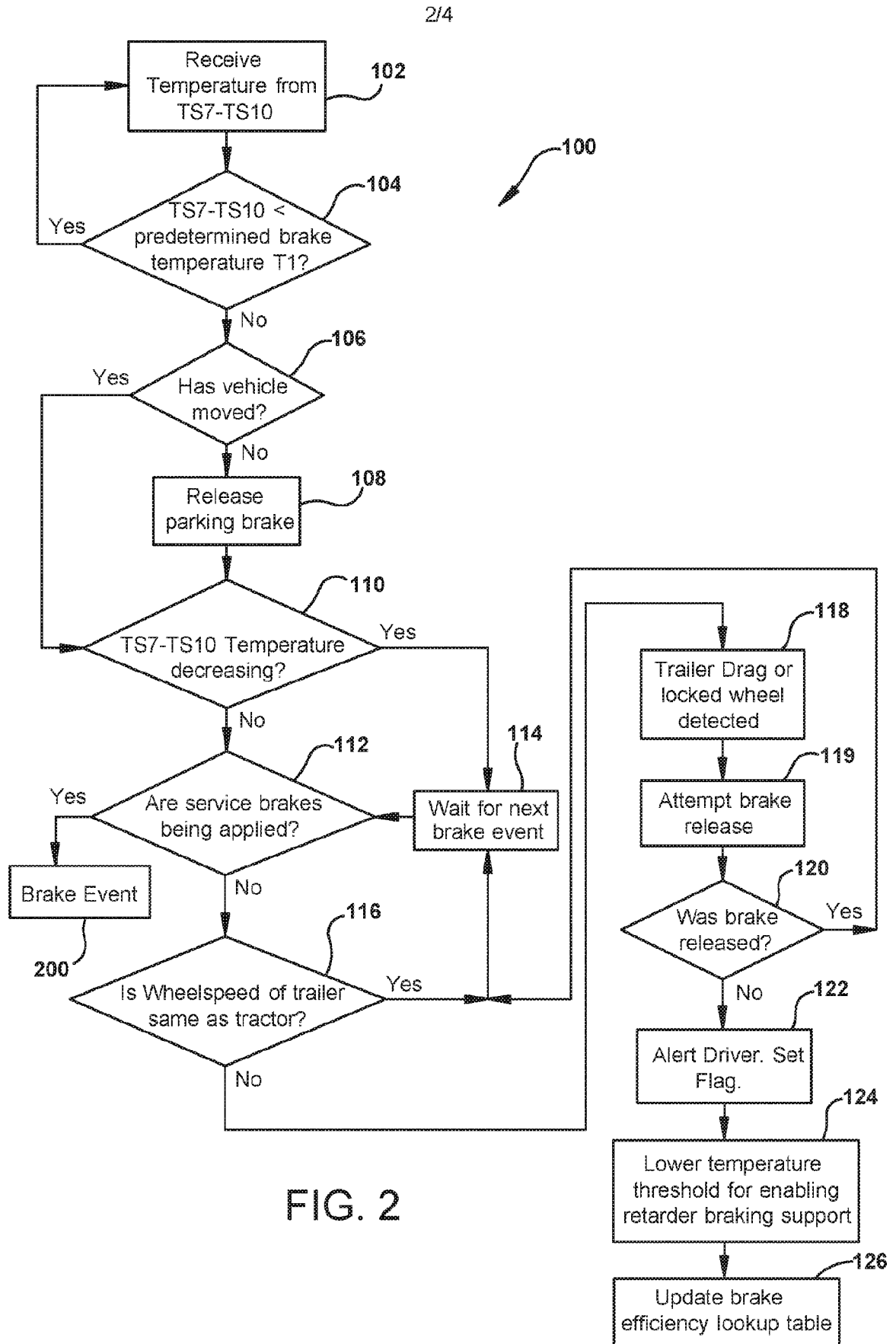
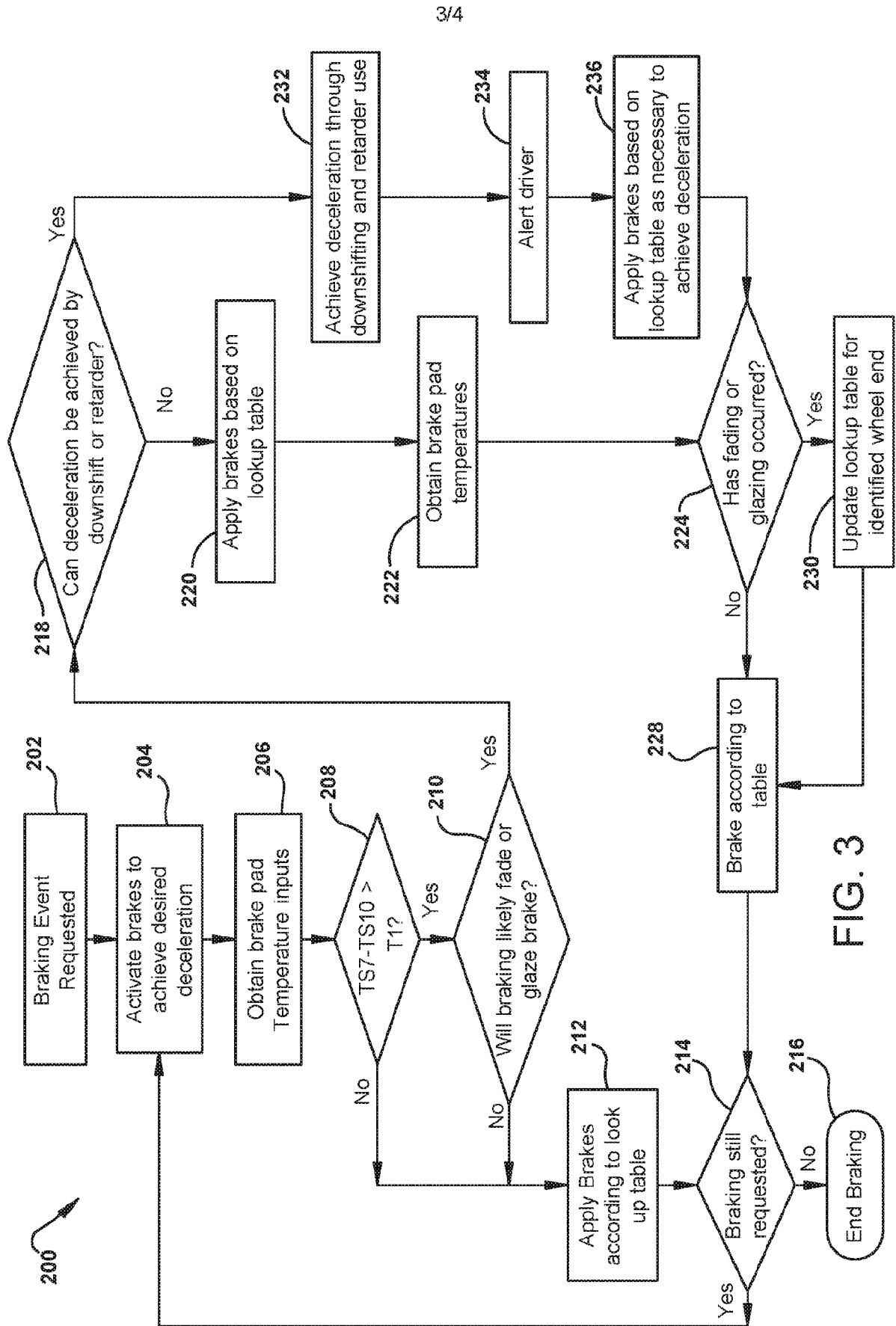
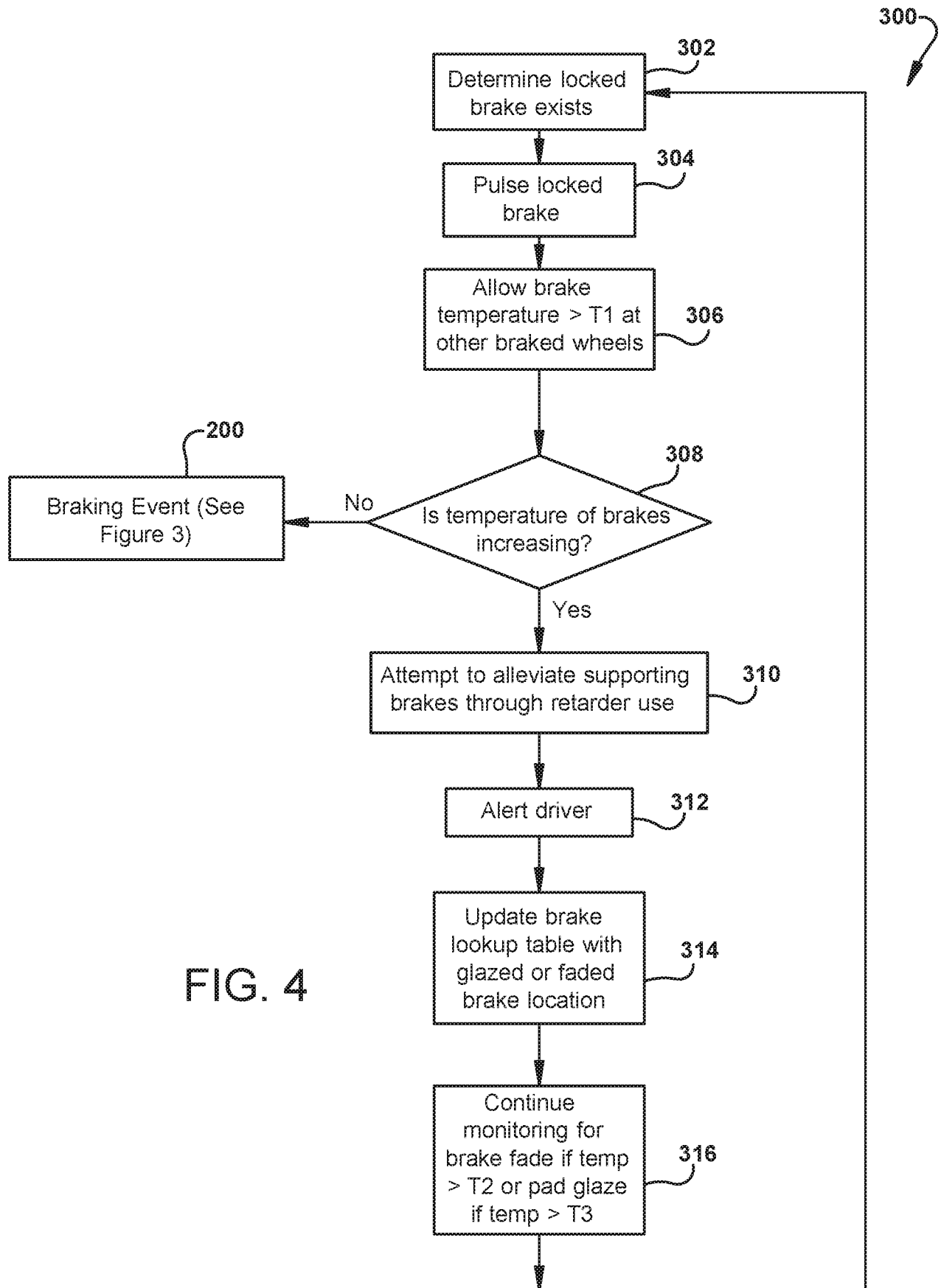


FIG. 1





PCT/US19/43882 30 August 2019 (30.08.2019)



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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/043882

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60T8/17 B60T8/88 B60T17/22
ADD.

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)
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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	EP 0 189 082 A2 (WABCO WESTINGHOUSE FAHRZEUG [DE]) 30 July 1986 (1986-07-30) page 17, paragraph 2 claims 1-29 figure	16 6,8,9,17 1-5,7, 10-15
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X Y A	US 2017/340908 A1 (HEATH JASON [US]) 30 November 2017 (2017-11-30) paragraphs [0034], [0049] figure 5	6,8 6,8,9 1-5
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

26 September 2019

Date of mailing of the international search report

08/10/2019

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/043882

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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