(12) UK Patent Application (19) GB (11) 2462839 (13) A

(43) Date of A Publication 24.02.2010

(21) Application No: 0815253.0

(22) Date of Filing: 21.08.2008

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(51) INT CL:
B62D 11/08 (2006.01)

(56) Documents Cited:
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(58) Field of Search:
UK CL (Edition X) **F2F**
INT CL **B62D**
Other: **Online: WPI & EPODOC**

(54) Abstract Title: **Tractor braking system having left and right hand brake circuits**

(57) A braking system on a tractor is provided wherein each one of a pair of braked wheels (12L, 12R) has a respective brake circuit (20,22) associated therewith. The system includes braking pressure creation means comprising a pedal-actuated valve (42) which regulates the output of a hydraulic pressure from an accumulator. Each brake circuit is connected to a solenoid-actuated directional control valve (28;58) which directs said hydraulic pressure to the associated wheel in response to a signal from a brake control unit (100) so as to brake that wheel. By routing the hydraulic pressure to the braked wheels using a solenoid-actuated valve or valves, the requirement to provide a separate pedal for each brake circuit is removed whilst still enabling single- or dual-wheel braking.

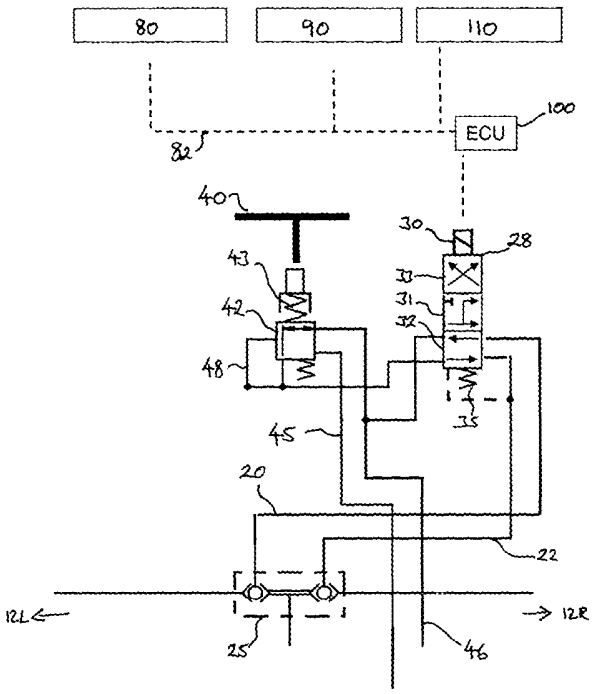

Fig. 2

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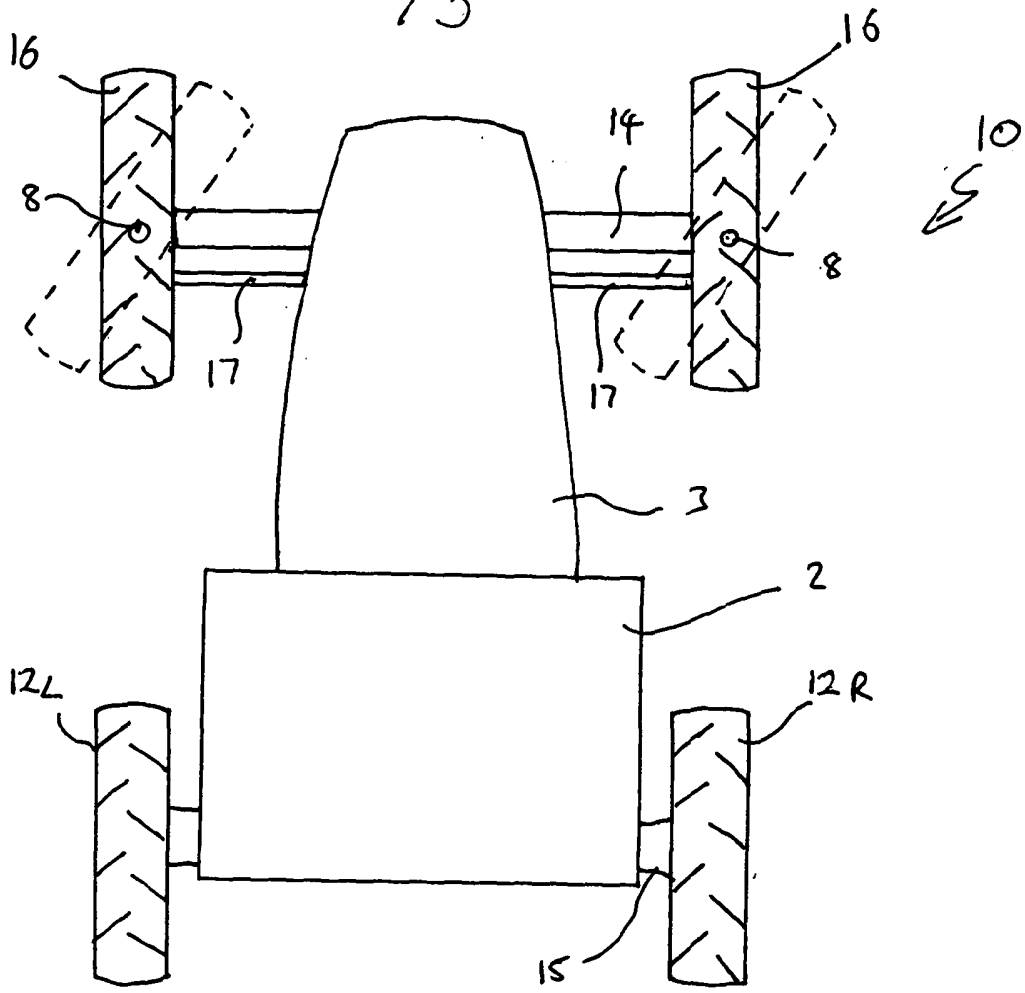

Fig. 1

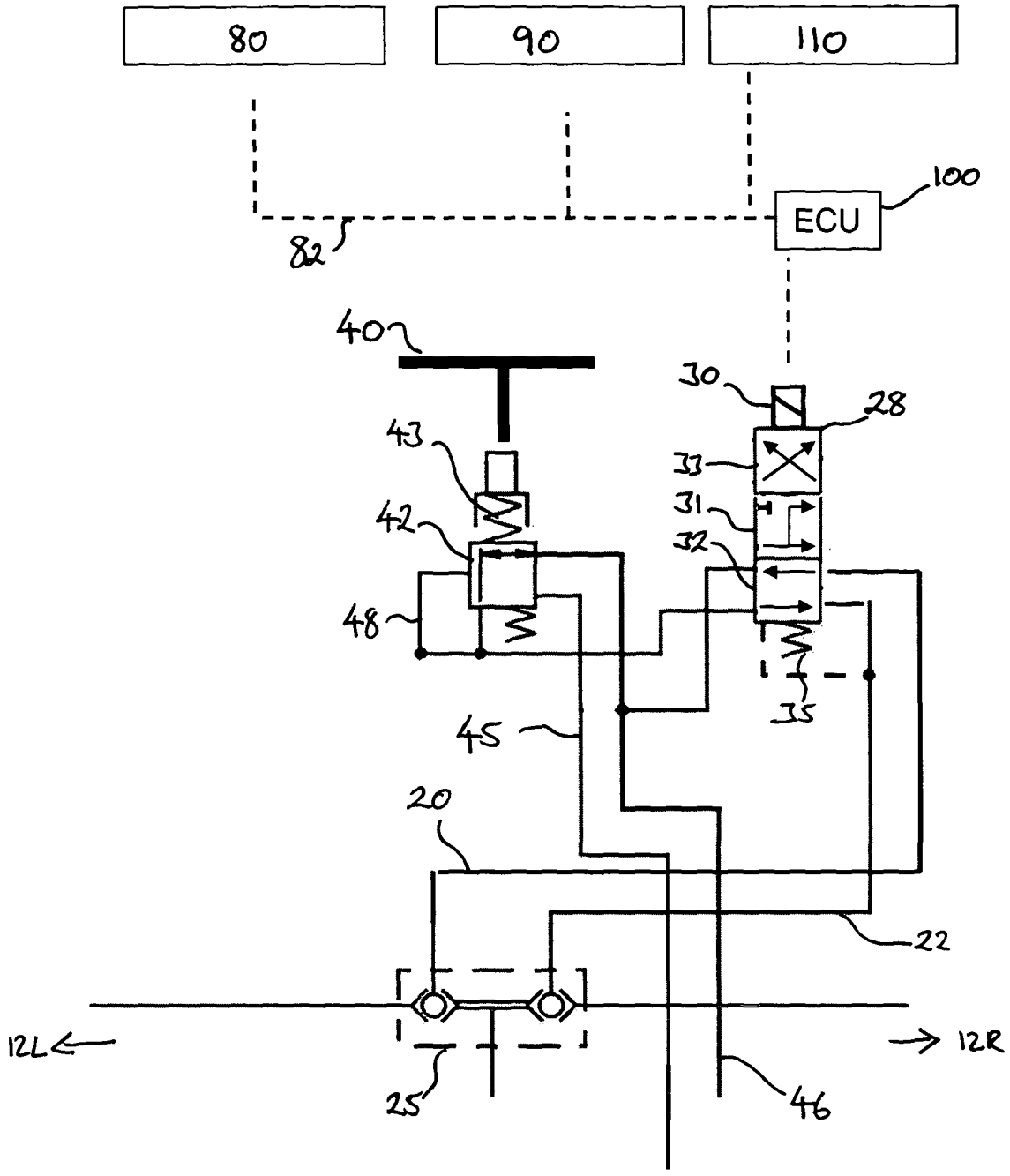
80
90
110
ECU
100
82
40
43
42
48
45
30
28
33
31
32
35
20
22
12L
12R
25
46

Fig. 2

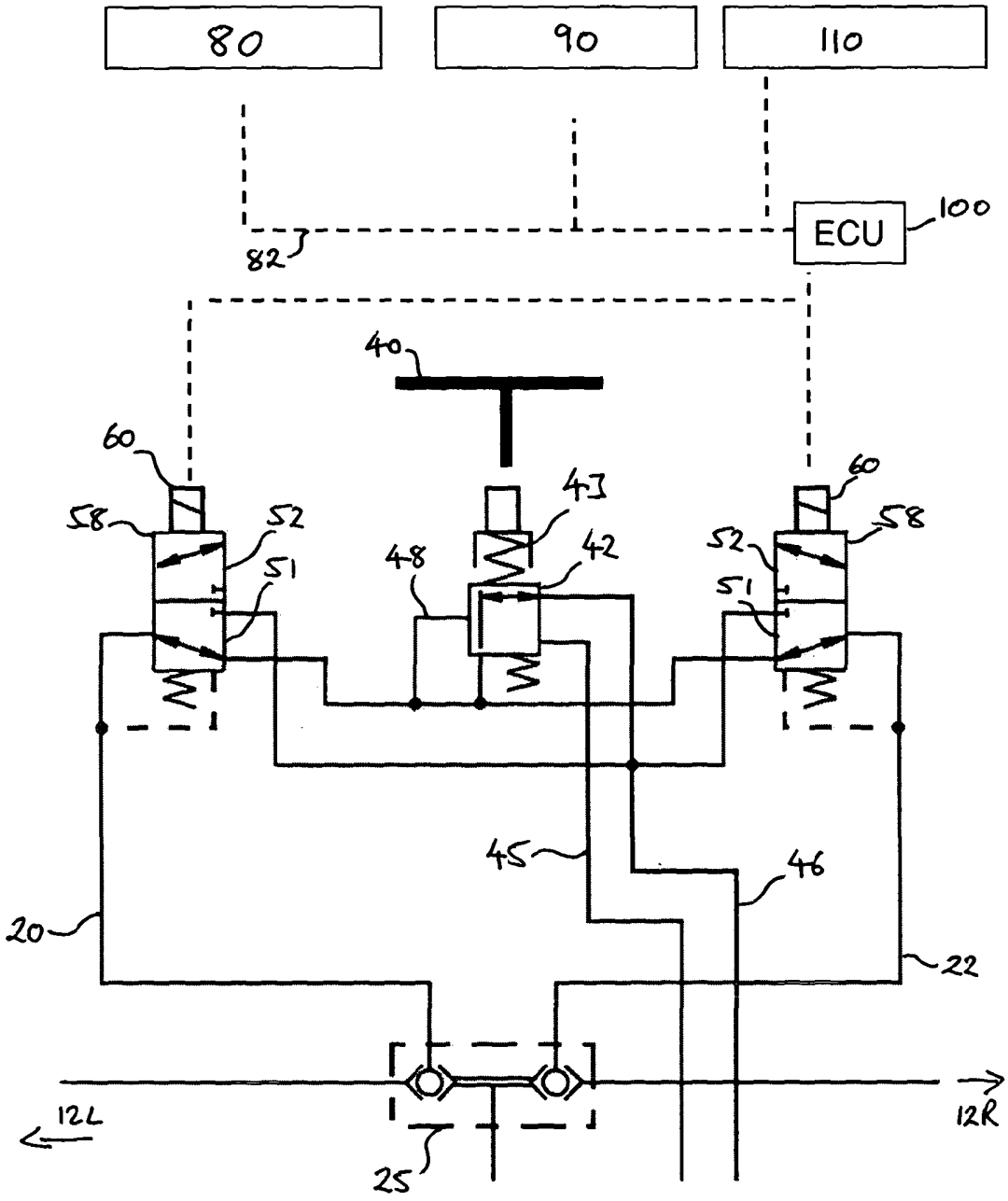

Fig. 3

DESCRIPTION

TRACTOR BRAKING SYSTEM

The invention relates to a braking system on a tractor comprising a left-hand and a right-hand brake circuit each associated with a respective braked wheel.

When steering tractors in low friction conditions such as in muddy fields the minimum turning radius significantly increases. Traditionally tractors comprise separate mechanical brake mechanisms and pedals for each of a left-hand braked wheel and a right-hand braked wheel. By braking on the left wheel only for example, the tractor is steered to the left thereby reducing the turning circle.

The respective pedals are positioned adjacent one another in the cab allowing the driver to either operate the pedals simultaneously with his right foot, or individually to assist the steering of the tractor. A locking bar is often provided to lock the two pedals together for road working to avoid the risk of braking only on one wheel.

Repetitive operations in the field such as turning on the headland during ploughing can require many hundreds of depressions of the individual brake pedals. This can be tedious for the driver over long periods of time.

Thus, it is an object of the invention to provide a tractor braking system which requires only one brake pedal whilst also allowing single-wheel braking.

According to the present invention there is provided a braking system on a tractor comprising a left-hand and a right-hand brake circuit each associated with a respective braked wheel, braking pressure creation means comprising a pedal-actuated valve which regulates the output of a hydraulic pressure from an accumulator, wherein each brake circuit is connected to a solenoid-actuated directional control valve which directs said regulated hydraulic pressure to the associated wheel in response to a signal from a brake control unit so as to brake that wheel. By routing the hydraulic pressure to the braked wheels using a solenoid-actuated valve or valves, the requirement to provide a separate pedal for each brake circuit is removed whilst still enabling single- or dual-wheel braking.

The single brake pedal is depressed by a driver and determines the pressure to be applied to the brakes. This pressure is routed to the individual braked wheels by the directional control

valve(s). The brake control unit activates the solenoid(s) to determine whether the hydraulic pressure created in response to depression of the pedal is routed to one of the brake circuits or both of the brake circuits.

Preferably, each brake circuit is connected to a common directional control valve having a first position in which the hydraulic pressure is directed to both wheels, a second position in which the hydraulic pressure is directed only to the right-hand braked wheel, and a third position in which the hydraulic pressure is directed only to the left-hand braked wheel. By employing a three-position valve in this way, the single brake pedal is always connected to at least one brake circuit, even in the event of the brake control unit failing.

Alternatively, each brake circuit is connected to a respective directional control valve. Each directional control valve may have a first position in which said hydraulic pressure is directed to the associated wheel, and a second position in which said hydraulic pressure is isolated from the associated wheel.

The system may be operable in a two-wheel braking mode in which the directional control valve associated with both brake circuits is maintained in the first position. For example, this may be selectable by a driver and can be used for road operation in which single-wheel braking should be avoided. Such a two-wheel braking mode may be automatically adopted when the speed of the tractor exceeds a predetermined threshold to avoid single-wheel braking at high speed.

In a preferred embodiment the tractor comprises a pair of steerable wheels which each pivot in unison around respective vertical axes through a range of steering angles, the system further comprising sensing means to sense the steering angle, wherein, in response to the sensed steering angle exceeding a threshold in one direction, the hydraulic pressure is directed only to the braked wheel corresponding to said one direction so that depression of the brake pedal serves to brake only that one wheel so as to assist steering of the tractor. Therefore, when the steering angle to the left exceeds a predetermined value, the brake control unit activates the solenoid(s) so that any hydraulic pressure created as a result of depressing the pedal is routed to the left-hand brake circuit so as to brake the left wheel.

The pedal-actuated valve is preferably a proportional pressure valve wherein the pressure fed to the directional control valve is dependent on the extent of depression of the pedal.

Specific embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic plan view of a tractor in accordance with the present invention;

Figure 2 is a diagram of a braking system fitted to the tractor of Figure 1 and in accordance with a first embodiment of the invention;

Figure 3 is a diagram of a braking system fitted to the tractor of Figure 1 and in accordance with a second embodiment of the invention.

With reference to Figure 1, a tractor 10 comprises a driver's cab 2, a bonnet 3, front axle 14 and rear axle 15. A pair of steerable wheels 16 are mounted on respective ends of the front axle 14. Hydraulically actuated steering rods 17 are mounted from the tractor chassis to the steerable wheels 16 which cause the wheels 16 to pivot in unison around respective vertical axes 8 through a range of steering angles.

Figure 1 shows the steerable wheels in a straight ahead direction as well as a direction pivoted to the right (shown by the dashed line).

The tractor further comprises a pair of rear braked wheels 12L and 12R mounted on respective ends of the rear axle 15.

Each of the rear braked wheels 12L, 12R have associated therewith braking means which serve to brake the associated wheel.

The tractor further comprises sensing means (not shown) mounted on the front axle 14 and serving to measure the rotational position of a vertical shaft to which one of the steerable wheels 16 is mounted. Such steering angle sensors are well known and details of such will not be described any further.

With reference to Figure 2, a braking system in accordance with a first embodiment of the invention comprises a left hand brake circuit 20 associated with the left hand braked wheel 12L, and a right hand brake circuit 22 associated with the right hand braked wheel 12R. Each of the brake circuits 20, 22 are connected to their respective wheels 12L, 12R via a trailer brake distribution unit 25. The braking means associated with each wheel 12L,12R is of known construction and a detailed description is not necessary for explaining the present

invention. It will be appreciated that the braking means may, for example, comprise a series of parallel brake discs and corresponding frictional brake pads which act together to brake the wheel in response to an applied hydraulic pressure transferred via the respective brake circuit.

Each brake circuit 20,22 is connected to a respective port of a three-position directional control valve 28. The directional control valve 28 is actuated by a solenoid 30. A brake control unit 100 is electrically connected to solenoid 30 and serves to control the positioning of the three position valve 28.

The three position directional control valve is biased to a first position referenced at 31 by a coil spring 35. By suitable application of an electrical signal from brake control unit 100 the directional control valve 28 can be moved into a second position referenced at 32 or a third position referenced at 33. Operation of the control valve 28 will be described later on.

A pedal 40 situated in the driver's cab 2 is mechanically linked to a proportional pressure valve 42. The pedal 40 is biased by a coil spring 43 into a lifted position wherein depression of the pedal 40 requires an applied force by the driver's foot.

The tractor transmission provides a high pressure system and which is connected to an input of the proportional pressure valve 42 via line 45. A low pressure hydraulic circuit provided by a fluid reservoir for example is connected to a second input of the proportional pressure valve 42 via line 46.

Depression of the pedal 40 by the driver adjusts the pressure delivered to the output of the proportional pressure valve 42 connected to hydraulic line 48. When the pedal is completely raised, that is when the driver is not applying a direct force, the output of the proportional pressure valve 42 is connected directly to the fluid reservoir 46. In the extreme opposite position wherein the pedal 40 is fully depressed, the output line 48 is connected directly to the high pressure circuit 45. It will be appreciated that the output pressure created at the proportional pressure valve 42 is dependant on the extent of the depression of the pedal 40.

Output line 48 is connected to a first input port of the directional control valve 28. The low pressure hydraulic line 46 is connected to a second input port of the directional control valve 28.

The system further comprises steering angle sensing means referenced at 80 in Figure 2. The steering angle is sensed in a known manner wherein the angular rotation of vertical shafts 8 is

measured at the front axle 14. This data is fed to the brake control unit 100 via either a wired link or a wireless link referenced at 82.

The speed of the tractor is also sensed by known sensing technology (referenced at 90) and such data is also fed to the brake control unit 100.

Operation of the brake system shown in Figure 2 will now described. Throughout the operation of the tractor 10 the brake control unit 100 continuously monitors the input data from steering angle sensor 80, vehicle speed sensor 90 and mode selector switch 110 which is located in the driver's cab 2. The collected data is entered into a lookup table, the output of which determines the desired position for the three position directional control valve 28. In the event of a desired change in the position of the control valve 28 the brake control unit sends an appropriate signal to solenoid 30 so as to actuate the desired change.

In a first scenario the tractor is driven on the field and the angle of steering does not exceed 90% of full lock to either the right of left hand side. In this situation there is no demand for single wheel braking and so the brake control unit 100 sets the directional control valve 28 to the first position 31. In this position the output from the proportional pressure valve 42 is fed via line 48 to both brake circuits 20, 22 so as to brake both wheels 12L,12R in response to a depressed pedal.

In a second scenario the steerable wheels 16 are steered to the right as shown by the dotted lines in Figure 1. When the steering angle exceeds the predetermined threshold of 90% of full lock the steering angle sensor 80 feeds this information to the brake control unit 100. In response to exceeding the predetermined threshold the brake control unit switches the directional control valve 28 to a second position referenced at 32. As a result of this the hydraulic pressure created at the proportional control valve 42 is fed via line 48 to the right hand brake circuit only. The left hand brake circuit 20 is connected to the low pressure line 46. Therefore when a driver depresses pedal 40 the resulting braking force is applied to the right hand braked wheel 12R only thereby assisting the steering of the tractor to the right hand side.

When the sensed steering angle drops below the predetermined threshold of 90% the brake control unit switches the directional control valve 28 back to the first position so as to resume two wheel braking.

In a third scenario the steerable wheels 16 are steered to the left hand side wherein the sensed steering angle data is fed by the steering angle sensor 80 to the brake control unit 100. In the event of the steering angle exceeding the predetermined threshold of 90% of full left hand lock the brake control unit switches the directional control valve 28 to a third position referenced at 33. In this case the hydraulic pressure created at the proportional pressure valve 42 is fed via line 48 to the left hand brake circuit 20 only. This enacts braking of the left hand braked wheel 12L only in response to depression of brake pedal 40 so as to assist steering of the tractor to the left.

In a fourth scenario the driver selects a two wheel braking mode using selector switch 110. Data corresponding with the selection of this mode is fed to the brake control unit 100. The directional control valve 28 is held in the first position 31 regardless of the steering angle sensed by steering angle sensor 80.

For any of the above scenarios if the sensed tractor speed exceeds a predetermined threshold of 5kpm then the brake control unit 100 will hold the directional control valve 28 in the first position 31 regardless of the sensed steering angle. This ensures that two wheel braking will always occur by depression of pedal 40 when the vehicle speed exceeds 5kph.

It will be understood that the predetermined threshold for the steering angles and tractor speed given above are by way of example only and different values may instead be selected. Moreover it is envisaged that the system may allow a driver to select predetermined thresholds and feed these into the brake control unit 100 using a suitable user interface.

In a second embodiment each brake circuit 20,22 is connected to a respective directional control valve 58. It will be understood that the pair of directional control valves 58 replaces the three way valve 28 of the first described embodiment. Each directional control valve 58 has a first position 51 in which the hydraulic pressure created at the proportional pressure valve 42 is directed to the brake circuit associated with that valve 58.

In a second position 52 the directional control valves 58 serve to isolate the associated brake circuit from the brake pedal. It will be understood that under normal operating conditions, at least one of the brake circuits 20,22 will be connected to the proportional pressure valve 42 by appropriate positioning of the control valves 58.

In a similar manner to the first described embodiment the brake control unit 100 is connected to the control valves 58 by a wired link which serves to activate respective solenoids 60 by the application of appropriate electrical signals.

From reading the present disclosure, other modification will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the field of tractor braking systems and component parts therefore and which may be used instead of or in addition to features already described herein.

CLAIMS

1. A braking system on a tractor comprising a left-hand and a right-hand brake circuit each associated with a respective braked wheel, braking pressure creation means comprising a pedal-actuated valve which regulates the output of a hydraulic pressure from an accumulator, wherein each brake circuit is connected to a solenoid-actuated directional control valve which directs said hydraulic pressure to the associated wheel in response to a signal from a brake control unit so as to brake that wheel.

2. A system according to Claim 1, wherein each brake circuit is connected to a respective directional control valve.

3. A system according to Claim 2, wherein each directional control valve has a first position in which said hydraulic pressure is directed to the associated wheel, and a second position in which said hydraulic pressure is isolated from the associated wheel.

4. A system according to Claim 1, wherein each brake circuit is connected to a common directional control valve having a first position in which the hydraulic pressure is directed to both wheels, a second position in which the hydraulic pressure is directed only to the right-hand braked wheel, and a third position in which the hydraulic pressure is directed only to the left-hand braked wheel.

5. A system according to any one of Claims 2, 3 or 4, comprising a two-wheel braking mode in which the directional control valve associated with both brake circuits is maintained in the first position.

6. A system according to Claim 5, wherein the two-wheel braking mode is automatically adopted when the speed of the tractor exceeds a predetermined threshold.

7. A system according to Claims 5 or 6, wherein the two-wheel braking mode can be selected by a driver-operated selector switch.

8. A system according to any one of Claims 2 to 7, wherein the tractor comprises a pair of steerable wheels which each pivot in unison around respective vertical axes through a range of steering angles, the system further comprising sensing means to sense the steering angle, wherein, in response to the sensed steering angle exceeding a threshold in one direction, the hydraulic pressure is directed only to the braked wheel corresponding to said

one direction so that depression of the brake pedal serves to brake only that one wheel so as to assist steering of the tractor.

9. A system according to any preceding claim, wherein the valve is a proportional pressure valve and wherein the pressure fed to the directional control valve is dependent on the extent of depression of the pedal.

10. A system according to Claim 9, wherein the accumulator is provided by the transmission of the tractor.

Application No: GB0815253.0 **Examiner:** Jason Clee

Claims searched: 1-10 **Date of search:** 18 December 2008

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-3 & 5-10	JP 11091616 A (ISEKI AGRICULT MACH) especially see the figures and abstract WPI AN 1999-282848 [24]
X	1-3 & 5-10	DE 4224887 A (DEERE & CO) especially see the figures and abstract WPI AN 1993-312682 [40]
X	1-3 & 5-10	JP 04252734 A (ISHIKAWAJIMA SHIBAURA MACH) especially see the figures and abstract
X	1 & 4-10	JP 08133038 A (ISEKI AGRICULT MACH) especially see the figures and abstract WPI AN 1996-305595 [31]
X	1 & 4-10	JP 06270832 A (YANMAR AGRICULT EQUIP) especially see the figures and abstract
X	1-3 & 8-10	JP 08133039 A (NIPPON DENSO CO) especially see the figures and abstract WPI AN 1996-305596 [31]

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

F2F

Worldwide search of patent documents classified in the following areas of the IPC

B62D

The following online and other databases have been used in the preparation of this search report

Online: WPI & EPODOC

International Classification:

Subclass	Subgroup	Valid From
B62D	0011/08	01/01/2006