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(71) **Applicant: AGCO CORPORATION** [US/US]; 4205 RIVER GREEN PARKWAY, DULUTH, Georgia 30096 (US).

(72) **Inventor: LEDUC, Alan Michael**; c/o AGCO Corporation, 420 W Lincoln Blvd, Hesston, Kansas 67062 (US).

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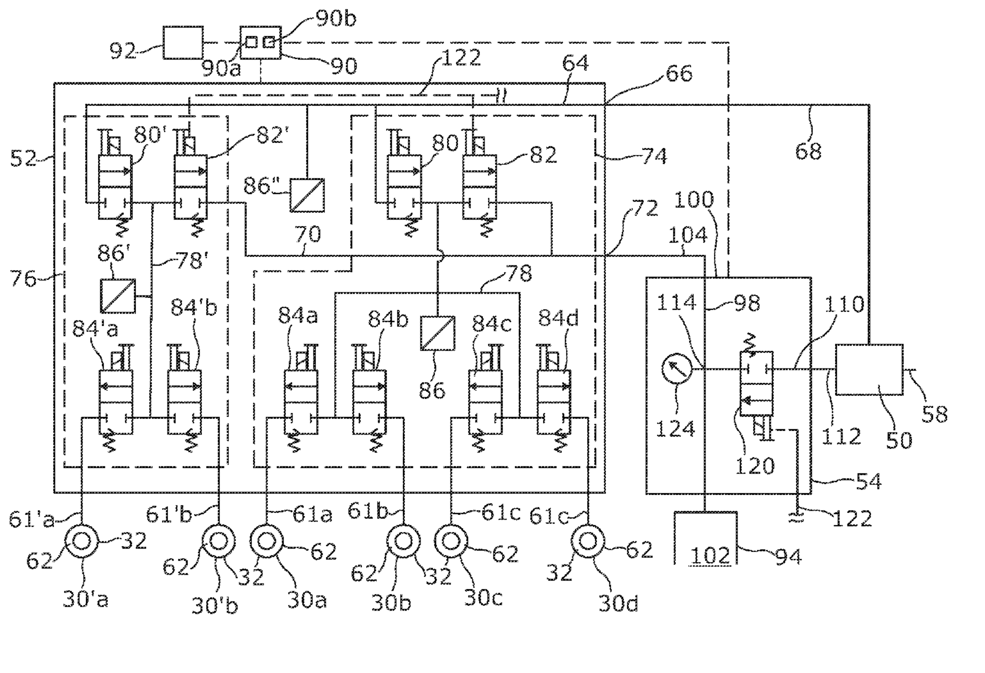

FIG. 3

(57) **Abstract:** A Central Tyre Inflation System and Method A central tire inflation system (CTIS) (10) for controlling air pressure of a tire (30) is configured to selectively deflate the tire by connecting it with an air exhaust outlet (94). A vacuum generator (54) is used to generate a vacuum in the flow path (61, 70, 78, 98, 104) between the tire and the exhaust outlet when the tire is being deflated. The vacuum generator may be a pneumatic vacuum generator having a venturi restriction (106, FIG. 5) in the flow path, a venturi pressurised air inlet (114) into the venturi restriction, and a vacuum generator valve (120) operative to selectively connect the inlet (114) with a source of pressurised air (50). A method of deflating a tire using a vacuum generator to reduce the air pressure below atmospheric in a region of a flow path between the at least one tire and an exhaust outlet whilst deflating the at least one tire is also disclosed.

WO 2023/223112 A1

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CENTRAL TIRE INFLATION SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/364828, filed 17 May 2022 which is incorporated herein by reference in its entirety.

FIELD

[0002] Embodiments of the present disclosure relate generally to central tire inflation systems and methods and to apparatus (including mobile machines, vehicles, and agricultural implements) incorporating such central tire inflation systems and methods.

BACKGROUND

[0003] Central tire inflation systems CTIS (also referred to as central tire pressure control systems) have been developed which allow tire pressures on apparatus, such as a mobile machine or vehicle, to be monitored and adjusted centrally. For agricultural applications in particular, it is desirable to be able to optimise tire inflation pressures for use in different environments. For example, for use in a field it is often desirable to use lower tire inflation pressures. This helps to spread the weight of the apparatus, reducing soil compaction, and maximises grip. Whereas, for use on a road or other hard surface higher tire pressures are required to provide stability, increased fuel efficiency and minimise tire wear. Accordingly, central tire inflation systems have been adopted for use on various agricultural apparatus, such as tractors, trailers, towed implements (including planters), sprayers, combined harvesters, forage harvesters and the like, which can be used to adjust tire pressures, e.g., when transitioning between road and field use.

[0004] In more sophisticated systems, tire pressures are automatically regulated in dependence on the load supported. For example, in a known planter having a toolbar supporting a number of row units, the toolbar has a central section and a pair of wing sections at either end that can be folded for transport and extended for use in a field. The central section is supported by a number of wheels and each wing section is supported by a wing wheel. A control system includes a system for adjusting the weight distribution across the toolbar. In one known arrangement there are a number weight distribution modes including a balanced mode and a controlled traffic mode. In the balanced mode weight is distributed over the entire working width of the planter toolbar, whilst in the controlled traffic mode weight is centralized from the wings to the machine centre. The balanced mode is typically adopted for field use whilst the controlled traffic mode is adopted for road use. Weighing cells are used to determine the load on each tire and the CTIS automatically adjusts the tire pressures ensuring that at least a minimum pressure required to support the respective load is maintained in each tire.

[0005] An important consideration for farmers is the time taken to inflate and deflate the tires when transitioning between road and field use. For use on the road, tires on a planter may be inflated to a pressure in the region of 4.2 bar (60 psi) and may be deflated to a pressure in the region of 1 bar (14.4 psi) or less for use in a field. In known CTISs, the tires are connected with atmosphere through an exhaust outlet during deflation and the rate of deflation is at least partly dependent on the differential between the tire pressure and atmospheric pressure. When a tire is fully inflated, the pressure differential is high and the rate of deflation correspondingly high but as the pressure in the tire falls, the pressure differential and rate of deflation also falls. As the tire pressure approaches atmospheric, the rate of deflation can become very low. Where tires take a long time to deflate to a target (set point) pressure, a farmer may have to choose between losing valuable planting time waiting for tire pressures to be reduced or using the tires at a higher than ideal pressure, increasing soil compaction.

BRIEF SUMMARY

[0006] In an aspect of the disclosure there is provided a central tire inflation system (CTIS) for controlling air pressure of at least one tire, the CTIS configured to selectively connect the at least one tire with an air exhaust outlet to deflate the tire, wherein a vacuum generator is provided in a flow path between the tire and the exhaust outlet, the vacuum generator operative in use when the at least one tire is being deflated to generate a vacuum in a region of the flow path.

[0007] By reducing the pressure in the flow path between the tire and the exhaust outlet below atmospheric, the speed at which air flows from the tire towards the exhaust outlet and the rate of deflation are increased. This reduces the time required to deflate the tire to a target pressure.

[0008] The region of the flow path in which the vacuum is generated may be located proximal to the exhaust outlet.

[0009] The vacuum generator may be located at an upstream side of the exhaust outlet.

[0010] The vacuum generator may be a pneumatic vacuum generator. The vacuum generator may be a venturi vacuum generator. The vacuum generator may comprise a venturi restriction in the flow path, a venturi pressurised air inlet into the venturi restriction, and a vacuum generator valve operative to selectively connect the venturi pressurised air inlet with a source of pressurised air. The venturi restriction may be located so as to generate a vacuum proximal the exhaust outlet. The venturi restriction may open into a chamber proximal the exhaust outlet, which chamber defines a flow path with a larger cross sectional area than the flow path through the venturi restriction.

[0011] The vacuum generator may be configured such that pressurised air entering the venturi restriction through the venturi pressurised air inlet flows in a direction toward the exhaust outlet.

[0012] The venturi restriction may have a first end and a second end, the first end of the venturi restriction being fluidly connectable with the at least one tire and the second end of the venturi restriction being fluidly connected with the exhaust outlet, the venturi pressurised air inlet opening into the venturi restriction at a position between the first and second ends.

[0013] The CTIS may have a main valve manifold comprising a plurality valves and which is configured to be operative in use to selectively connect the at least one tire to an exhaust line fluidly connected to the first end of the venturi restriction to deflate the at least one tire. The main valve manifold may comprise at least one deflation valve operative in use to selectively connect the at least one tire to the exhaust line. The at least one deflation valve and the vacuum generator valve may be operably coupled such that actuation of the at least one deflation valve to fluidly connect the at least one tire to the exhaust line results in actuation of the vacuum generator valve to fluidly connect the venturi pressurised air inlet to the source of pressurised air. The valve manifold may be configured to regulate the pressure of a plurality of tires. The valve manifold may comprise at least two deflation valves, each deflation valve being operative in use to selectively connect at least one of the plurality of tires to the exhaust line. Each of the deflation valves may be operatively coupled with the vacuum generator valve such that actuation of either one, or both, of the deflation valves to fluidly connect at least one of the plurality of tires to the exhaust line results in actuation of the vacuum generator valve to fluidly connect the inlet to the second source of pressurised air. The, or each, deflation valve may be operatively coupled with the vacuum generator valve by a jumper harness.

[0014] The vacuum generator and the main valve module may be provided as separate units, each having their own housing. The main valve manifold may define an outlet for the exhaust line which is fluidly connected to an exhaust flow passage inlet of the vacuum generator by a fluid line, the exhaust flow passage inlet being fluidly connected to the first end of the venturi restriction. Alternatively, the vacuum generator may be incorporated with the main valve manifold in a single housing.

[0015] The CTIS may comprise a controller operatively connected with the at least one deflation valve to control operation of the at least one deflation valve. The controller may be operatively connected with the vacuum generator valve to control operation of the vacuum generator valve.

[0016] The CTIS may be configured to selectively connect the at least one tire with a source of pressurised air to inflate the at least one tire. In which case, the same source of pressurised air may be used for tire inflation and for the vacuum generator.

[0017] The controller may be operatively connected with a plurality of valves in the main manifold and with sensors for monitoring the pressure in each of the plurality of tires and configured to automatically regulate the pressures in each of the plurality of tires.

[0018] In accordance with a further aspect of the disclosure, there is provided apparatus comprising at least one pneumatic tire and a CTIS according to the previous aspect of the disclosure operatively connected with the at least one pneumatic tire. The apparatus may comprise a machine or a vehicle. The apparatus may comprise an agricultural machine or agricultural vehicle. The apparatus may comprise an agricultural implement such as a planter having a plurality of row units mounted to a toolbar. The apparatus may comprise a combination of an agricultural implement and vehicle, such as a tractor, towing the implement.

[0019] In accordance with a further aspect of the disclosure, there is provided an agricultural planter comprising a central tire inflation system (CTIS) for controlling air pressure of at the least one tire, the CTIS configured to selectively connect the at least one tire with an air exhaust outlet to deflate the tire, wherein a vacuum generator is provided in a flow path between the tire and the exhaust outlet, the vacuum generator operative in use when the at least one tire is being deflated to generate a vacuum in a region of the flow path.

[0020] In accordance with a still further aspect of the invention, there is provided a method of deflating a tire using a CTIS configured to selectively connect at least one tire with an exhaust outlet to deflate the tire, the method comprising using a vacuum generator to reduce the air pressure below atmospheric in a region of a flow path from the at least one tire to the exhaust outlet whilst deflating the at least one tire.

[0021] The method may comprise using the vacuum generator to reduce the pressure below atmospheric in a region of the flow path proximal to the exhaust outlet. The region may be immediately upstream of the exhaust outlet.

[0022] The method may comprise using a CTIS as defined above in relation to the first mentioned aspect of the disclosure.

[0023] Within the scope of this application it should be understood that the various aspects, embodiments, examples and alternatives set out herein, and individual features thereof may be taken independently or in any possible and compatible combination. Where features are described with reference to a single aspect or embodiment, it should be understood that such features are applicable to all aspects and embodiments unless otherwise stated or where such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] One or more embodiments of the disclosure will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0025] FIG. 1 is a perspective view of a planter incorporating a CTIS according to an aspect of the disclosure;

[0026] FIG. 2 is a perspective view of components of the CTIS of FIG. 1 shown isolated from the remainder of the planter;

[0027] FIG.3 is a schematic representation of the CTIS of FIGS. 1 and 2;

[0028] FIG.4 is a perspective view of a vacuum generator forming part of the CTIS of FIGS. 1 to 3; and

[0029] FIG.5 is wireframe view of the vacuum generator of FIG. 4 showing internal details.

DETAILED DESCRIPTION

[0030] Embodiments of the disclosure will now be described with reference to a CTIS 10 on an agricultural planter 12. However, the teachings herein can be applied to a CTIS for use on any type of apparatus having pneumatic tires including, without limitation, any suitable mobile machines and vehicles. Aspects of the disclosure are particularly, but not exclusively, suited to application on mobile agricultural machines and/or agricultural vehicles intended for use both on and off-road and where there is a need to vary tire inflation pressures significantly when transitioning between road use and off-road use. Examples of such agricultural machines include, without limitation, self-propelled agricultural machines such as combine harvesters and towed agricultural implements such as planters. Examples of such agricultural vehicles include, without limitation, tractors, sprayers, and loaders and the like. The disclosure is also relevant to CTIS on apparatus comprising a combination of a towed agricultural implement and a towing vehicle, such as a tractor.

[0031] With reference to FIGs. 1 and 2, an agricultural planter 12 is provided with a CTIS 10 and a weight distribution system 14.

[0032] The planter 12 includes a frame 16 and a hitch 18 for attachment to a tractor or other towing vehicle or device (not shown). In the illustrated embodiment, the planter 12 is configured for planting row crop seeds and has a number of row units 20 mounted to a transverse toolbar 22. The toolbar is divided into three sections, a central section 22a and a pair of wing sections 22b, 22c, the wing sections located at opposite ends of the central section 22a. Each section 22a, 22b, 22c has a two-part frame consisting of a main toolbar 24 and a seed toolbar 26 which holds the row units. The position of each of the row units 20 is independently adjustable relative to the respective seed toolbar 26 and the position of each of the seed toolbars 26 is adjustable relative to the respective main toolbar 24. The central section 22a extends in a transverse direction of the planter and the wing sections 22b, 22c are each movable between a working position as shown where they extend in the transverse direction, generally in-line with the central section 22a, and a transport or folded position in which they extend generally in a longitudinal direction X of the planter 12.

[0033] The planter 12 is supported for movement over the ground by a number of wheels 30, 30', each having a pneumatic tire 32. The main toolbar 24 of the central section is supported on four centre section wheels 30 arranged in two tandem pairs including a right front wheel 30a, a right rear wheel 30b, a left front wheel 30c, and a left rear wheel 30d. The main toolbar 24 of each wing section 22b, 22c is supported on a single wing wheel 30', denoted as 30'a, 30'b on either wing section. In other embodiments, each wing section may be supported by more than one wing wheel 30'.

[0034] The weight distribution system 14 includes fluid actuators (e.g. hydraulic cylinders) 40, each operative between the central section 22a of the toolbar and a respective one of the wing sections 22b, 22c to vary the weight distribution across the toolbar and hence the loading on the various wheels 30, 30'.

[0035] Each row unit 20 includes seed delivering elements such as seed hoppers 42 and seed metering discs of conventional design. Furthermore, main seed hoppers 44 and one or more storage tanks 46 for fluids for delivery by the row units 20 may be supported on the frame 16.

[0036] The weight distribution system 40 and the seed and fluid delivery arrangements of the planter 12 are not described in detail as they are not relevant to the present disclosure.

[0037] The CTIS 10 includes a source of pressurised air 50, which may be an accumulator or reservoir, a main manifold 52, a vacuum generator 54, and a rotary coupling 56 for each wheel 30, 30'. The accumulator 50 may be supplied with pressurised air from a pressurised air source of the tractor or other towing vehicle. Typically, the planter 12 may be towed by a tractor having a pressurised air supply system which is connectable to the accumulator via a hose 58 and releasable connector 60 in a known manner. Alternatively, a compressor may be provided on the planter to supply the accumulator. Such a compressor may be hydraulically driven. It will be appreciated that any suitable source of pressurised air can be used, especially for applications other than a planter.

[0038] Each rotary coupling 56 fluidly connects a respective pneumatic wheel line 61 to an interior reservoir 62 of the pneumatic tire 32 on the respective wheel 30, 30'. In a known manner, each rotary coupling 56 enables air to flow into and out of the interior reservoir 62 to inflate and deflate the tire 32. In an embodiment, each rotary coupling 56 may be provided as part of a unit or weighing cell including a sensor for measuring the load on the wheel.

[0039] Details of the CTIS will now be described with reference principally to FIGs.3 to 5.

[0040] The main valve manifold 52 has a pressurised air supply passage 64 having an inlet 66 connected with the accumulator 50 by an air supply line 68 and an air exhaust passage 70 having an outlet 72. The air exhaust passage 70 is connected with an exhaust outlet or vent 94 through which air is exhausted to atmosphere and which is provided as part of the vacuum generator 54, as will be described later. The exhaust outlet 94 may be termed an atmospheric exhaust outlet.

[0041] The main valve manifold 52 includes a number of valves configured to enable each of the wheel lines 61 (and hence the interior reservoir 62 of the respective tire 32 on the associated wheel 30, 30') to be selectively connected with the air supply passage 64 in order to inflate the respective tire 32 or with the air exhaust passage 70 in order to deflate the respective tire 32. All the valves in the main valve module are electronically controllable two position solenoid valves movable between a closed position, as shown, in which flow through the valve is prevented and an open position in which flow through the valve is permitted. In the embodiment shown, the valves are each biased to the closed position and actuated by means of a solenoid to the open position. The valves in the main valve manifold are divided into a centre section module (indicated by broken line 74) which is used to regulate the pressure of the tires of the centre section wheels 30a, 30b, 30c, 30d, and a wing section wheel module (indicated by broken line 76) which is used to regulate the pressures of the tires of the wing wheels 30'a, 30'b.

[0042] The centre section module 74 has a first intermediate flow passage 78, a first inflation valve 80, and a first deflation valve 82. The first inflation valve 80 is operable in use to selectively connect the first intermediate flow passage 78 with the air supply passage 64 when open and to disconnect the first intermediate flow passage 78 from the air supply passage 64 when closed. In a similar manner, the first deflation valve 82 is operable in use to selectively connect the first intermediate flow passage 78 with the air exhaust passage 70 when open and to disconnect the first intermediate flow passage 78 from them air exhaust passage 70 when closed. The centre section module includes four centre section wheel valves 84a, 84b, 84c, 84d, each being operative to selectively connect a respective one of the wheel lines 61a, 61b, 61c, 61d to the first intermediate flow passage 78 when open and to disconnect the respective wheel line from the first intermediate flow passage 78 when closed. By appropriate actuation of the first inflation valve 78, the first deflation valve 82, and the centre section wheel valves 84a, 84b, 84c, 84d, any one of more of the tires 32 on the centre section wheels can be connected to the air supply passage 64 to be inflated or to the air exhaust passage 70 to be deflated.

[0043] In normal use, the first inflation valve 80 and first deflation valve 82 remain closed and the wheel valves 84a-84d are opened so that the wheel lines 61a-61d are fluidly connected to the intermediate flow passage 78. In this configuration, the pressures between the tires of the centre section wheels 30a-30d are equalised. If it is necessary to inflate the tires on the centre section wheels 30a-30d, the first inflation valve 80 is opened to connect the first intermediate flow passage 78 with the air supply passage 64 and the source of pressurised air 50 whilst the first deflation valve 82 remains closed. When the tires 32 on the centre section wheels reach the desired pressure, the first inflation valve 80 is closed. If it is necessary to deflate the tires 32 on the centre section wheels, the first deflation valve is opened whilst the first inflation valve 80 remains closed to connect the first intermediate flow passage 78 to the air exhaust passage 70 and hence the exhaust outlet 94 to atmosphere. When the tires 32 on the centre section wheels reach the desired pressure, the first deflation valve 80 is closed.

[0044] A first pressure sensor 86 is fluidly connected to the first intermediate flow passage 78 to sense the pressure in the first intermediate flow passage 78. With the centre section wheel valves 84a-84d opened and the first inflation valve 80 and the first deflation valve 82 closed, the pressure in the first intermediate flow passage 78 is indicative of the pressure of the tires of the centre section wheels. Accordingly, the first pressure sensor 86 can be used to monitor the tire pressures of the centre section wheels 30a-30d.

[0045] The wing section module 76 is constructed and operates in a similar manner to the centre section module 74 but has only two wing section wheel valves 84'a, 84'b, one for each of the wing wheels 30'a, 30'b. In alternative embodiments where the wing sections have more than one wheel each, the wing section module 76 will have a corresponding number of wing section wheel valves. The wing section module 76 has a second intermediate flow passage 78', a second inflation valve 80', and a second deflation valve 82'. The second inflation valve 80' is operable in use to selectively connect the second intermediate flow passage 78' with the air supply passage 64 when open and to disconnect the second intermediate flow passage 78' from the air supply passage 64 when closed. In a similar manner, the second deflation valve 82' is operable in use to selectively connect the second intermediate flow passage 78' with the air exhaust passage 70 when open and to disconnect the second intermediate flow passage 78' from the air exhaust passage 70 when closed. The wing section wheel valves 84'a, 84'b are each operative to selectively connect a respective one of the wing section wheel lines 61'a, 61'b to the second intermediate flow passage 78' when open and to disconnect the respective wing section wheel line from the second intermediate flow passage 78' when closed. By appropriate actuation of the second inflation valve 78', the second deflation valve 82', and the wing section wheel valves 84'a, 84'b any one or both of the tires 32 on the wing section wheels 30'a, 30'b can be connected to the air supply passage 64 to be inflated or to the air exhaust passage 70 to be deflated.

[0046] Operation of the valves in the wing section wheel module 76 to inflate or deflate the tires on the wing wheels 30'a, 30'b is similar to that of the centre section module 74. In normal use on a field, the second inflation valve 80' and second deflation valve 82' remain closed and the wing wheel valves 84'a and 84'b are opened so that the wheel lines 61'a and 61'b are fluidly connected to the second intermediate flow passage 78’. In this configuration, the pressures between the tires of the wing section wheels 30’a, 30’b are equalised. If it is necessary to inflate the tires on the wing section wheels 30’a, 30’b, the second inflation valve 80’ is opened to connect the second intermediate flow passage 78’ with the air supply passage 64 and the source of pressurised air 50 whilst the second deflation valve 82’ remains closed. When the tires 32 on the wing section wheels reach the desired pressure, the second inflation valve 80’ is closed. If it is necessary to deflate the tires 32 on the wing section wheels, the second deflation valve 82’ is opened whilst the second inflation valve 80’ remains closed to connect the second intermediate flow passage 78’ to the air exhaust passage 70 and hence the exhaust outlet 94 to atmosphere. When the tires 32 on the wing section wheels reach the desired pressure, the second deflation valve 80’ is closed.

[0047] A second pressure sensor 86’ is fluidly connected to the second intermediate flow passage 78’ to sense the pressure in the second intermediate flow passage 78’. At least when the wing section wheel valves 84’a, 84’d are opened and the second inflation and deflation valves 80’ 82’ closed, the pressure in the second intermediate flow passage 78’ is indicative of the pressure in the tires of the wing wheels 30’a, 30’b. Accordingly, the second pressure sensor 86’ can be used to monitor the tire pressures of the wing wheels.

[0048] A third pressure sensor 86’’ is fluidly connected with the air supply passage 64 to monitor the air pressure in the air supply passage 64. The third pressure sensor 86’’ can be used to monitor system pressure. For example, when the pressurised air is supplied by a towing tractor, the system pressure will need to be maintained above a predetermined minimum (e.g. 6.9 bar or 100 psi) as required to keep the air brakes on the tractor unlocked and/or to meet other system requirements.

[0049] All of the valves are electronically controllable, two position solenoid valves operatively connected with an electronic controller (indicated schematically at 90). The controller 90 may comprise or be connected with a HMI, indicated schematically at 92, which includes a display screen visible to an operator of the machine and user input means. The display screen may be a touch screen through which the operator is able to provide inputs or other user input means may be provided which could be physically separate from the display screen. The controller 90 provides the control logic for the CTIS functionality. The controller 90 may be provided on the planter 12 or on a tractor or other towing device to which the planter is connected and may be part of larger control system for the planter 12 and/or towing vehicle. The controller 90 may include a first controller 90 on the planter and a second controller on the towing vehicle.

[0050] In one embodiment, the controller 90 comprises one or more processors, such as processor 90a, input/output (I/O) interface(s), and memory 90b, all coupled to one or more data busses. The memory 90b may include any one or a combination of volatile memory elements (e.g., random-access memory RAM, such as DRAM, and SRAM, etc.) and non-volatile memory elements (e.g., ROM, hard drive, tape, CDROM, etc.). The memory 90b may store a native operating system, one or more native applications, emulation systems, or emulated applications for any of a variety of operating systems and/or emulated hardware platforms, emulated operating systems, etc. In one embodiment the memory comprises an operating system and CTIS (tire pressure) control software. It should be appreciated by one having ordinary skill in the art that in some embodiments, additional or fewer software modules (e.g., combined functionality) may be stored in the memory 90b or additional memory. In some embodiments, a separate storage device may be coupled to the data bus, such as a persistent memory (e.g., optical, magnetic, and/or semiconductor memory and associated drives).

[0051] Each of the pressure sensors 86, 86′, 86′′ provides an input signal to the controller 90 indicative a detected pressure in the respective flow passage 78, 78′, 64.

[0052] Electronic communications among the various components of the CTIS 12 may be achieved over a controller area network (CAN) bus or via a communications medium using other standard or proprietary communication protocols (e.g., RS 232, etc.). Communication may be achieved over a wired medium, wireless medium, or a combination of wired and wireless media.

[0053] The processor 90a may be embodied as a custom-made or commercially available processor, a central processing unit (CPU) or an auxiliary processor among several processors, a semiconductor based microprocessor (in the form of a microchip), a macro processor, one or more application specific integrated circuits (ASICs), a plurality of suitably configured digital logic gates, and/or other well-known electrical configurations comprising discrete elements both individually and in various combinations to coordinate the overall operation of the controller 90.

[0054] Use of separate valve modules 74, 76 to control the pressures in the centre section wheels 30a-30d and the wing wheels 30’a, 30’b makes it possible to inflate the wing wheels whilst deflating the centre section wheels or vice versa.

[0055] The vacuum generator 54 is provided in the exhaust flow path between the air exhaust passage 70 and an exhaust outlet 94 through which air exhausted from one or more tires 30, 30’ is vented to atmosphere and is operative to generate a vacuum in the exhaust flow path when a tire is being deflated. In this embodiment, the vacuum generator 54 is provided as a separate unit from the main valve manifold 51 and has a housing 96 separate from the main manifold housing. Within the vacuum generator housing 96, a vacuum generator main exhaust air passage 98 extends from an inlet 100 to the exhaust outlet 94. A filter 102 is provided at the exhaust outlet 94 to prevent debris from being admitted into the exhaust flow path where it could potentially be drawn into the main valve manifold and damage the valves. The vacuum generator main exhaust air passage inlet 100 is connected to the outlet 72 of the air exhaust passage 70 of the main manifold 52 by a suitable exhaust line 104, which may be a flexible hose.

[0056] A venturi restriction 106 (best seen in FIG. 5) is provided in the main vacuum generator exhaust air passage 98. The venturi restriction 106 opens into a larger diameter chamber 108 immediately upstream of the exhaust outlet 94. The venturi restriction 106 has a cross-sectional area which is smaller than the cross-sectional area of the air exhaust flow path upstream of the restriction (e.g. in the exhaust line 104 and/or at the inlet 100) and the exhaust outlet chamber 108.

[0057] The vacuum generator has a pressurised air passage 110 connected at an inlet end to the source of pressurised air 50 by a pressurised air line 112. In an embodiment, the pressurised air line 112 may be a flexible hose. The pressurised air passage 110 opens at a pressurised air venturi inlet 114 into the venturi restriction 106 at a position partway along its length between a first end 116 and a second end 118 of the venturi restriction 106. The flow of air along the pressurised air passage 110 into the venturi restriction 106 is regulated by a vacuum generator valve 120. As illustrated in this embodiment, the vacuum generator valve 120 may be a two position, electronically actuatable solenoid valve which is movable between a closed position, as shown in FIG. 3, in which flow of pressurised air through the valve 120 into the venturi restriction is prohibited and an open position in which pressurised air is able to flow from the pressurised air source 50 into the venturi restriction 106 along the pressurised air passage 110 through the vacuum generator valve 120. The vacuum generator valve 120 is biased to the closed position and is moved to the open position by a solenoid when actuated.

[0058] Operation of the vacuum generator valve 120 may be coordinated with operation of the first and second deflation valves 82, 82’ so that the vacuum generator valve 120 is opened whenever either one or both of the first and second deflation valves 82, 82’ is opened to deflate tires on the planter. In use, when one or more tires are being deflated, the vacuum generator valve 120 is opened to admit a flow of pressurised air from the source of pressurised air 50 into the venturi restriction 106 through the pressurised air venturi inlet 114. The pressurised air flowing into the venturi restriction 106 through inlet 114 flows towards the exhaust outlet 94. This flow of pressurised air increases the speed of the air flowing through the venturi restriction 106 resulting in a reduction of pressure to create a vacuum. The reduction in pressure at or close to the exhaust outlet 94 increases the pressure differential between the interior cavity 62 of the respective tire or tires being deflated and the region where the vacuum is generated and so increases the rate of deflation. This effect is particularly beneficial as the pressure in the respective tire or tires approaches atmospheric.

[0059] In the present embodiment, the vacuum generator valve 120 is operatively connected with the first and second deflation valves 82, 82’ through a wiring harness (a jumper harness indicated schematically by dashed line 122) configured such that when either one or both of the first and second deflation valves 82, 82’ are actuated to the open position, the vacuum generator valve 120 is also actuated to the open position but without compromising the ability to control actuation of the first and second deflation valves 82, 82’ independently of one another. The wiring harness 122 may comprise a suitable arrangement of diodes to ensure that the first and second deflation valves 82, 82’ can be controlled independently of one another. An advantage of this arrangement is that separate control of the vacuum generator valve 120 by the controller 90 is not required, allowing for a simplified construction and control algorithm. However, in alternative arrangements operation of vacuum generator valve 120 is regulated by the controller 90 so that it need not be opened whenever one of the first and second deflation valves 82, 82’ is actuated. This would allow for more sophisticated control strategies regarding use of the vacuum generator. For example, the vacuum generator 54 could be actuated only when the pressure in the tire or tires being deflated falls below a given value. This would be beneficial in reducing the consumption of the pressurised air, leading to greater overall efficiency.

[0060] It is expected that the pressure differential between the exhaust outlet 94 and the exhaust air passage 98 upstream of the pressurised air venturi inlet 114 will ensure that pressurised air entering the venturi restriction 106 through the pressurised air venturi inlet 114 flows towards the exhaust outlet 94. However, the configuration of the pressurised air venturi inlet 114 and the vacuum generator as a whole can be modified to ensure that the pressurised air flows towards exhaust outlet 94 on entering the venturi restriction 106.

[0061] A pressure/vacuum gauge 124 is operatively connected with the venturi restriction 106 to measure the pressure /vacuum in the venturi restriction in use. A dial gauge is illustrated but the gauge could be an electronic gauge or sensor operatively connected with the controller 90 to provide an input signal for use as part of a control function.

[0062] An advantage of the embodiment as described above in which the vacuum generator 54 is provided in a separate housing 96 from the main valve manifold 52 is that it can be easily provided as an upgrade to an existing CTIS system comprising the main valve manifold 52, without the need to re-design the main valve manifold. The vacuum generator 54 could therefore be provided as an after-market upgrade or provided as an optional feature for the CTIS. However, in other embodiments, the functional components of the vacuum generator 54 can be integrated into a common housing with the main valve manifold 52 to provide a more compact arrangement.

[0063] It will be appreciated that a vacuum generator 94 to increase the rate of deflation as described above could be incorporated into a range of different CTISs, including systems where the pressure in individual tires on the apparatus are adjusted independently of one another and could be adopted in CTIS on other types of apparatus including other types agricultural implement or vehicles, such as tractors.

[0064] Various modifications can be made to embodiments described as will be clear to those skilled in the art. For example, alternative valve arrangements can be adopted to enable any one or more tires to be selectively connected to a source of pressurised air 50 to be inflated or to an exhaust outlet 94 via a vacuum generator 54 to be deflated.

CLAIMS

What is claimed is:

1. A central tire inflation system (CTIS) for controlling air pressure of at least one tire, the CTIS configured to selectively connect the at least one tire with an air exhaust outlet to deflate the tire, the CTIS comprising a vacuum generator operative in use when the at least one tire is being deflated to generate a vacuum in a region of a flow path between the at least one tire and the exhaust outlet.

2. A CTIS as claimed in claim 1, wherein the region of the flow path in which the vacuum is generated is located proximal to the exhaust outlet.

3. A CTIS as claimed in claim 1 or claim 2, wherein the vacuum generator is a pneumatic vacuum generator.

4. A CTIS as claimed in claim 3, wherein the vacuum generator is a venturi vacuum generator comprising a venturi restriction in the flow path, a venturi pressurised air inlet into the venturi restriction, and a vacuum generator valve operative to selectively connect the venturi pressurised air inlet with a source of pressurised air.

5. A CTIS as claimed in claim 4, wherein the venturi restriction is located proximal the exhaust outlet.

6. A CTIS as claimed in claim 4 or claim 5, wherein the CTIS includes a main valve manifold comprising at least one deflation valve operative in use to selectively connect the at least one tire to an exhaust line fluidly connected to a first end of the venturi restriction to deflate the at least one tire.

7. A CTIS as claimed in claim 6, wherein the vacuum generator is at least partially provided in a housing separate from a housing of the main valve manifold.

8. A CTIS as claimed in claim 6 wherein the vacuum generator and the main valve manifold are provided in a common housing.

9. A CTIS as claimed in any one of claims 6 to 8, wherein the CTIS comprises a controller operatively connected with the at least one deflation valve to control operation of the at least one deflation valve.

10. A CTIS as claimed in claim 9, wherein the controller is operatively connected with the vacuum generator valve to control operation of the vacuum generator valve.

11. A CTIS as claimed in claim 9, wherein the at least one deflation valve and the vacuum generator valve are operably coupled such that actuation of the at least one deflation valve to fluidly connect the at least tire to the exhaust line results in actuation of the vacuum generator valve to fluidly connect the venturi pressurised air inlet to the source of pressurised air.

12. Apparatus comprising at least one tire and a CTIS according to any one of the preceding claims for regulating the pressure in the at least one tire.

13. An agricultural planter comprising at least one tire and a central tire inflation system (CTIS) for controlling air pressure of the at least one tire, the CTIS configured to selectively connect the at least one tire with an air exhaust outlet to deflate the tire, the CTIS comprising a vacuum generator operative in use when the at least one tire is being deflated to generate a vacuum in a region of a flow path between the at least one tire and the exhaust outlet.

14. An agricultural planter according to claim 13, wherein the CTIS is a CITS according to any one or more of claims 1 to 11.

15. A method of deflating a tire using a CTIS configured to selectively connect the at least one tire with an exhaust outlet to deflate the tire, the method comprising using a vacuum generator to reduce the air pressure below atmospheric in a region of a flow path between the at least one tire and the exhaust outlet whilst deflating the at least one tire.

16. A method as claimed in claim 15, wherein the method comprises using the vacuum generator to reduce the pressure below atmospheric in a region of the flow path proximal

to the exhaust outlet, wherein the region may be immediately upstream of the exhaust outlet.

17. A method as claimed in claim 15 or claim 16, wherein the method comprises using a CTIS according to any one of claims 1 to 11 to deflate the tire.

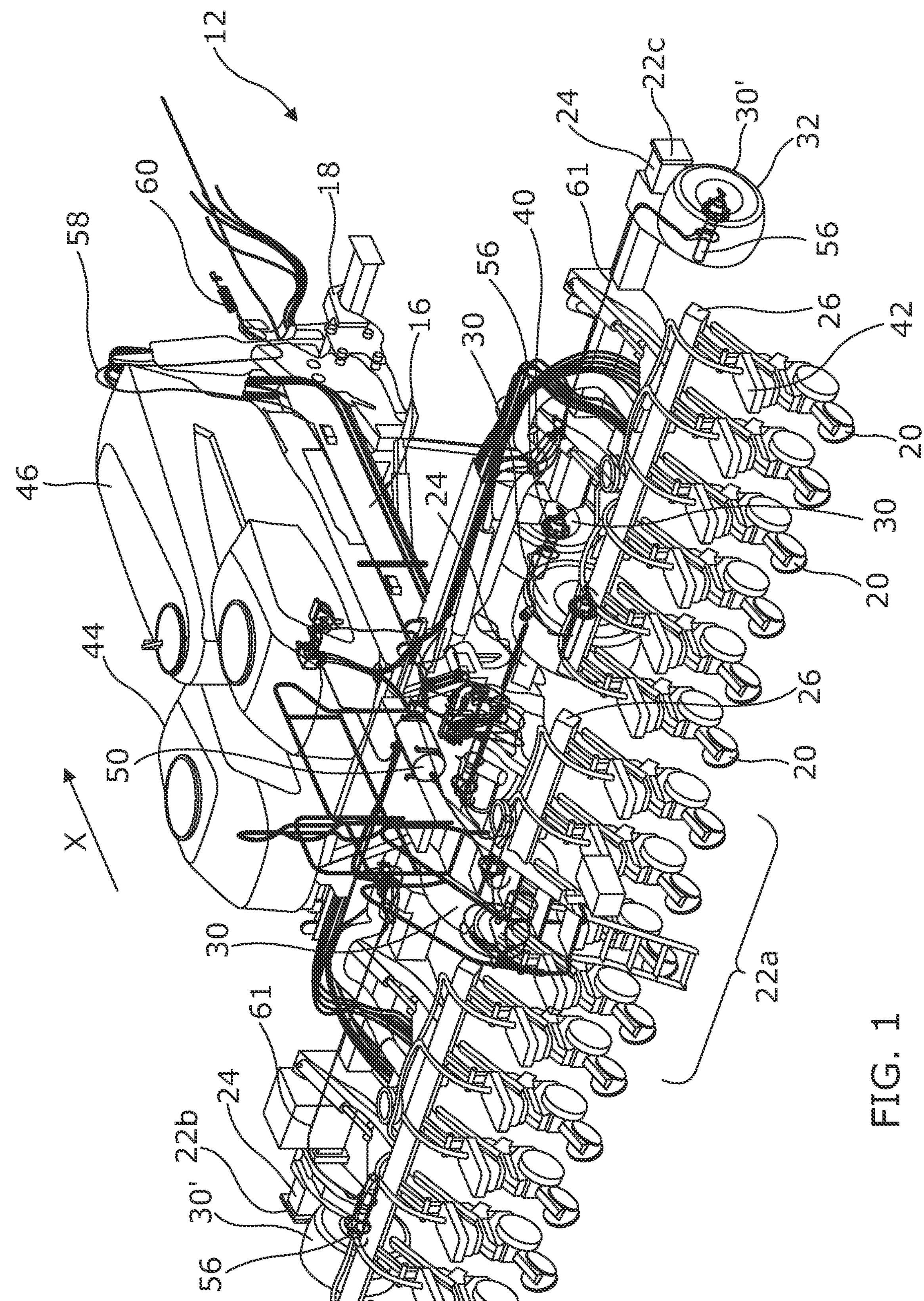
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FIG. 1

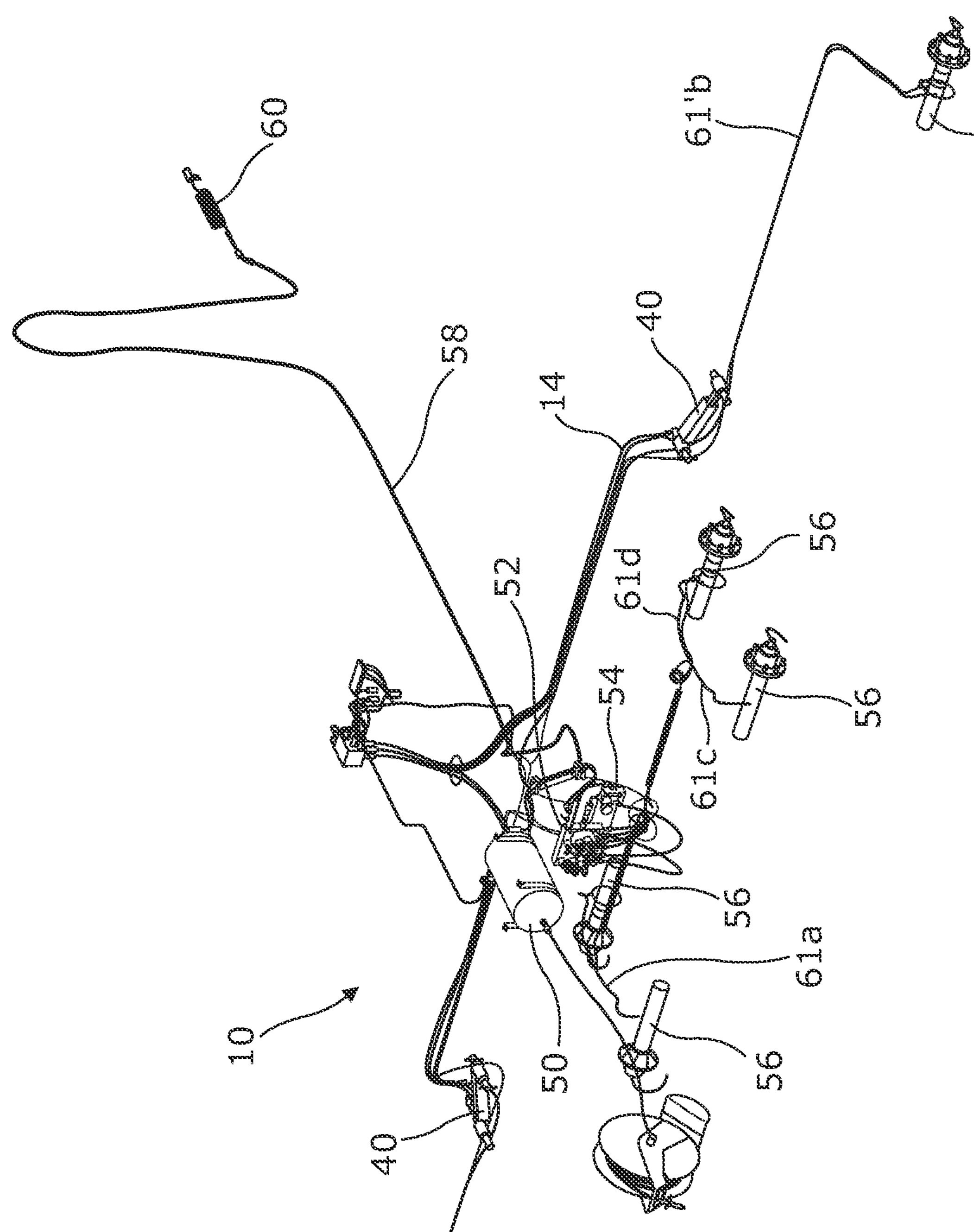
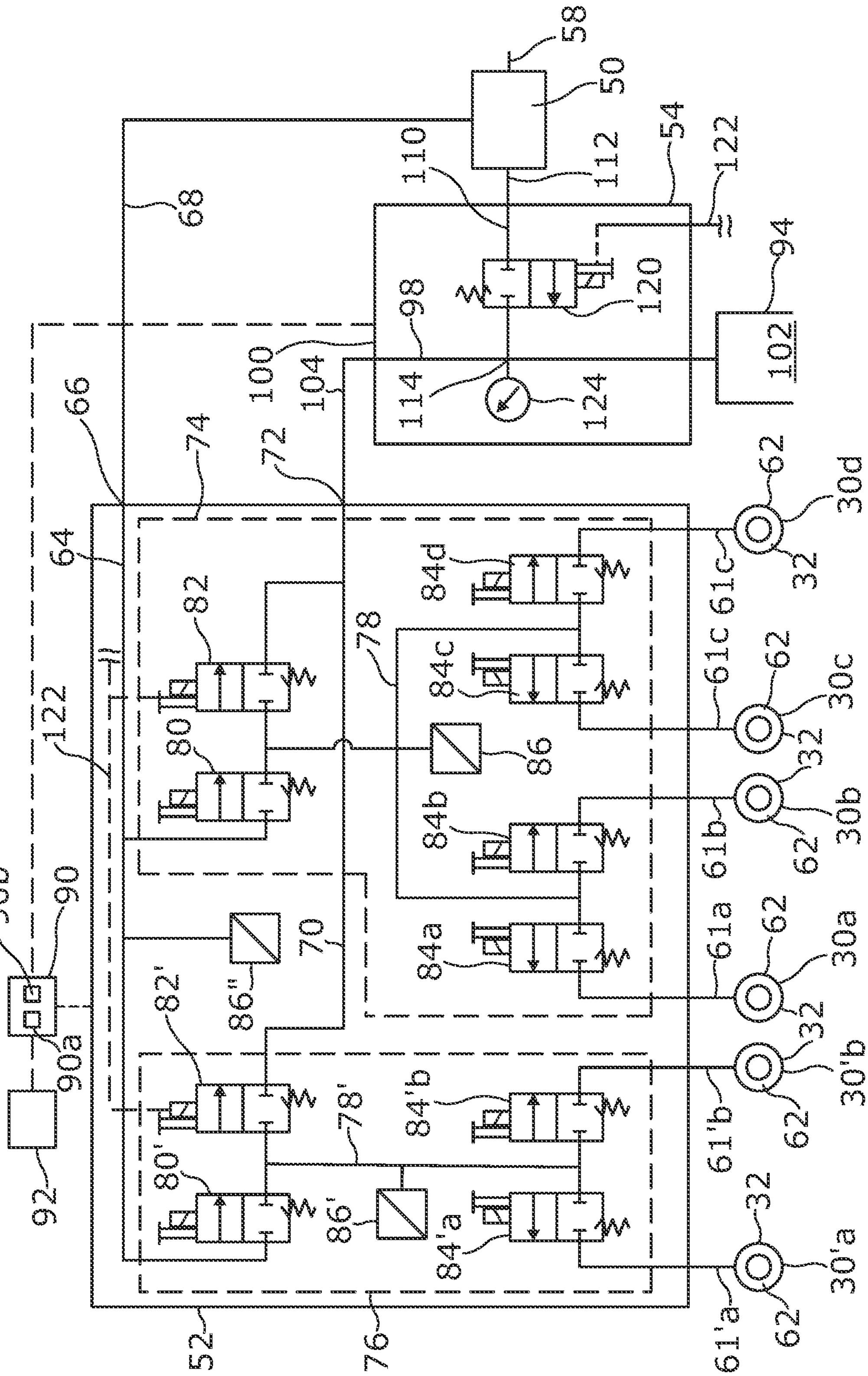


FIG. 2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76
61'a

FIG. 3

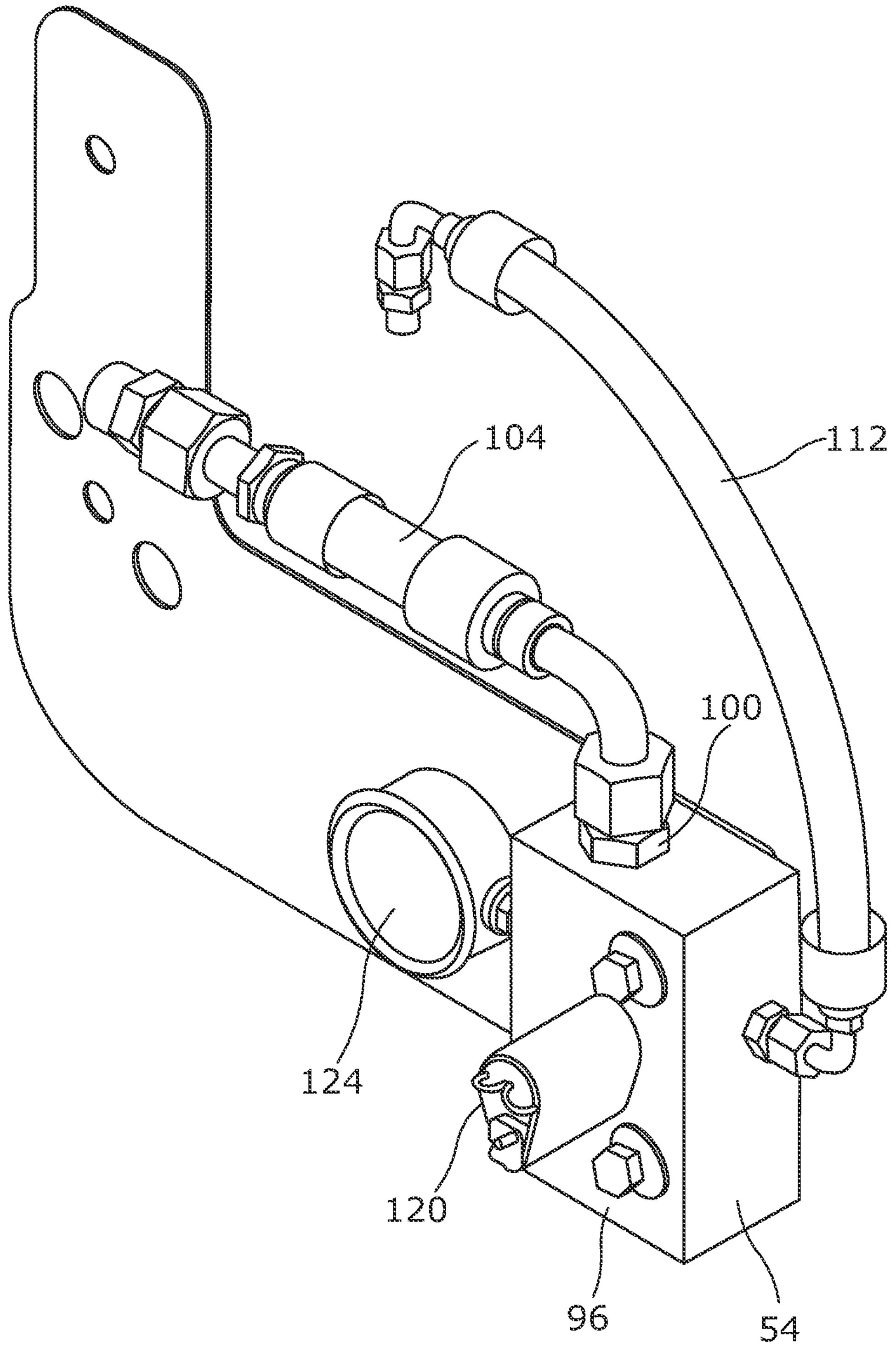

FIG. 4

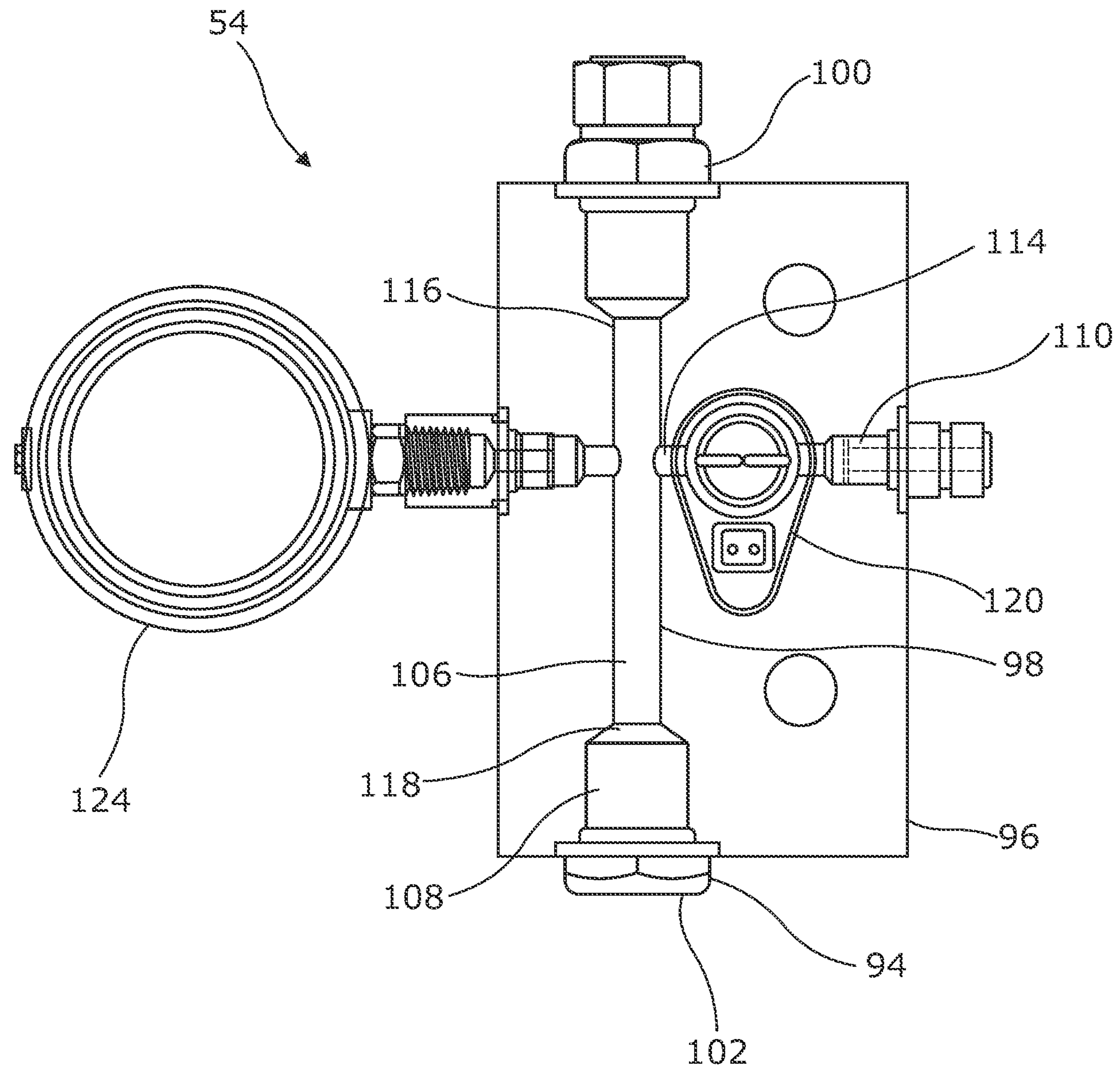

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/053485

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60C23/00
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)
B60C

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	US 2004/103939 A1 (BEAU HENRI [FR]) 3 June 2004 (2004-06-03)	1-3, 12-17
A	paragraph [0030]; figure 1	4-8

X	US 5 544 688 A (FREIGANG ALAN R [US] ET AL) 13 August 1996 (1996-08-13)	1-3,12, 15-17
A	figure 1	4-11

X	US 5 244 027 A (FREIGANG ALAN R [US]) 14 September 1993 (1993-09-14)	1-3,12, 15-17
A	figures 1-4	4-11

X	US 10 828 941 B2 (FIAT RICERCHE [IT]) 10 November 2020 (2020-11-10)	1-3,12, 15-17
A	figure 24	4-11

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2023	30/06/2023
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Schork, Willi

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/053485

C(Continuation). **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 922 946 A (BOULICAULT JEAN-MICHEL [FR]) 8 May 1990 (1990-05-08) column 3, line 22 - line 29; figure 1 -----	1-3,12, 15-17 4-11
Y	EP 3 530 492 A1 (CNH IND ITALIA SPA [IT]) 28 August 2019 (2019-08-28) figures 2-4 -----	4-11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2023/053485

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 2004103939	A1	03-06-2004	EP	1377467	A1	07-01-2004
			FR	2822918	A1	04-10-2002
			KR	20030095394	A	18-12-2003
			US	2004103939	A1	03-06-2004
			WO	02078984	A1	10-10-2002
US 5544688	A	13-08-1996	AR	000379	A1	18-06-1997
			AU	692000	B2	28-05-1998
			BR	9505444	A	28-10-1997
			CA	2164534	A1	24-06-1996
			CN	1130246	A	04-09-1996
			DE	69516648	T2	28-12-2000
			EP	0718128	A1	26-06-1996
			ES	2146292	T3	01-08-2000
			JP	H08240275	A	17-09-1996
			KR	960023955	A	20-07-1996
			US	5544688	A	13-08-1996
			ZA	9510805	B	27-08-1996
US 5244027	A	14-09-1993	AR	246711	A1	30-09-1994
			AT	144942	T	15-11-1996
			AU	649937	B2	02-06-1994
			BR	9203491	A	13-04-1993
			CA	2077035	A1	04-03-1993
			CN	1070878	A	14-04-1993
			DE	69215046	T2	28-05-1997
			EP	0531069	A2	10-03-1993
			ES	2093793	T3	01-01-1997
			IL	102852	A	28-11-1994
			JP	3122911	B2	09-01-2001
			JP	H05193315	A	03-08-1993
			KR	930005809	A	20-04-1993
			US	5244027	A	14-09-1993
			ZA	926595	B	19-03-1993
US 10828941	B2	10-11-2020	CN	108349338	A	31-07-2018
			EP	3380344	A1	03-10-2018
			US	2018345740	A1	06-12-2018
			WO	2017089915	A1	01-06-2017
US 4922946	A	08-05-1990	EP	0296017	A1	21-12-1988
			FR	2616194	A1	09-12-1988
			US	4922946	A	08-05-1990
EP 3530492	A1	28-08-2019	BR	102019001822	A2	20-08-2019
			CN	110091681	A	06-08-2019
			EP	3530492	A1	28-08-2019
			US	2019232735	A1	01-08-2019