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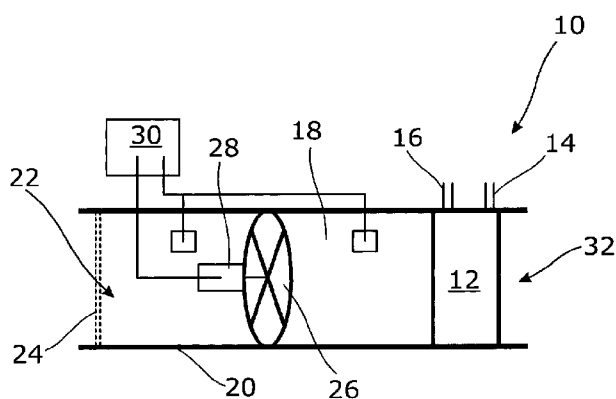


Figure 1

(57) Abstract: A cooling unit for an agricultural vehicle, the cooling unit including: a grid for allowing air to enter the unit whilst limiting the ingress of debris into the unit, a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger, a duct situated between the grid and the heat exchanger, a fan situated in the duct, the fan driven by a motor to move air along the duct and across the heat exchanger, a first pressure sensor for measuring the pressure (p_1) in the duct between the grid and the fan, and/or a second pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger, a controller in communication with first and/or second pressure sensor to monitor the pressure p_1 and/or p_2 , wherein the fan is operable by the controller in a first direction to draw air through the grid and across the heat exchanger and in a second direction for a predetermined period of time upon the pressure p_1 falling below a first predetermined value and/or the pressure p_2 falling below a second predetermined value.



CONTROL OF COOLING FAN ON PRESSURE

The present invention relates to cooling systems for commercial agricultural vehicles and in particular, but not exclusively, to a cooling unit for a tractor and method of
5 controlling the same.

Commercial agricultural vehicles, such as tractors, frequently operate in off-highway environments in which a substantial volume of debris lies on the ground. For example, during crop harvesting, a large volume of waste product is generated by the harvester.
10 This waste falls to the ground behind the harvester. When tractor wheels subsequently pass over the debris it can be thrown into the air and drawn into the tractor's cooling system. This can cause the cooling system to become blocked which can limit the efficiency of the heat exchanger and potentially damage the engine.

15 The cooling system typically comprises a heat exchanger for removing heat from the engine coolant, a fan for blowing air across the heat exchanger to increase the rate of heat exchange, and a grid positioned upstream of the fan to prevent larger debris from entering the cooling system.

20 Blockage can occur upstream of the fan at the grid, or downstream of the fan at the heat exchanger.

It is known to monitor the fan motor's current and to reverse the direction of the fan in the event that the current drawn by the motor increases in response to a blocking of
25 the cooling system. However, reversing the fan is only effective at removing debris from the over-pressure side of the cooling package, that is to say, from the grid.

It is an objective of the present invention to at least mitigate one or more of the above problems.

30

According to a first aspect of the invention there is provided a cooling unit for an agricultural vehicle, the cooling unit including:

a grid for allowing air to enter the unit whilst limiting the ingress of debris into the unit,

a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger,

a duct situated between the grid and the heat exchanger,

5 a fan situated in the duct, the fan driven by a motor to move air along the duct and across the heat exchanger,

a first pressure sensor for measuring the pressure (p_1) in the duct between the grid and the fan, and/or a second pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger,

10 a controller in communication with first and/or second pressure sensor to monitor the pressure p_1 and/or p_2 ,

wherein the fan is operable by the controller in a first direction to draw air through the grid and across the heat exchanger and in a second direction for a predetermined period of time upon the pressure p_1 falling below a first predetermined value and/or the pressure p_2 falling below a second predetermined value.

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According to a second aspect of the invention there is provided a cooling unit for an agricultural vehicle, the cooling unit including:

a grid for allowing air to enter the unit whilst limiting the ingress of debris into the unit,

20

a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger,

a duct situated between the grid and the heat exchanger,

a fan situated in the duct, the fan driven by a motor to move air along the duct and across the heat exchanger,

25

a pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger,

a controller in communication with the pressure sensor to monitor the pressure p_2 ,

30

wherein the controller generates a heat exchanger blockage warning in the event that the pressure p_2 rises above a predetermined value.

According to a third aspect of the invention there is provided a method of detecting and/or removing debris from the cooling unit of an agricultural vehicle, the cooling unit including:

a grid for allowing air to enter the unit whilst limiting the ingress of debris into the unit,

a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger,

5 a duct situated between the grid and the heat exchanger,

a fan situated in the duct, the fan driven by a motor to move air along the duct and across the heat exchanger,

a pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger,

10 a controller in communication with the pressure sensor to monitor the pressure p_2 ,

the method including the steps of:

operating the fan in a first direction to draw air through the grid and across the heat exchanger,

15 operating the fan in a second reversed direction when the pressure p_2 drops below a first predetermined value.

Preferably, the method includes the step of generating a heat exchanger blockage warning when the pressure p_2 rises above a second predetermined value.

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Preferably, the unit includes an additional pressure sensor measuring the pressure p_1 in the duct between the grid and the fan, the method including the step of operating the fan in a second reversed direction when the pressure p_1 drops below a third predetermined value.

25

Advantageously, the monitoring of the duct pressures allows the location of the blockage to be determined and the appropriate action to be taken. Specifically, in the event that the blockage is located at the grid (the pressures between the grid and the fan, and the fan and the heat exchanger drop) the fan is reversed to clear the blockage.

30 In the event that the blockage is located at the heat exchanger (the pressure between the fan and the heat exchanger rises) a driver warning is generated. This allows the vehicle user to manually clear the blockage.

The invention will now be described, by way of example only, and with reference to the following drawings, in which:

Figure 1 is a schematic representation of the cooling unit according to the present invention, shown in an unblocked state;

Figure 2 is a schematic representation of the cooling unit of Figure 1, shown in a first blocked state; and

Figure 3 is schematic representation of the cooling unit of Figure 1 shown in a second blocked state.

Figure 1 shows a cooling unit indicated generally at 10. The unit is typically situated under the hood of an agricultural vehicle (not shown for clarity). The purpose of the unit 10 is to receive heated coolant fluid from the vehicle engine or oil cooler and transfer heat from the coolant fluid to the ambient air.

Accordingly, the unit 10 is provided with a heat exchanger 12 which has a coolant fluid inlet 14 and outlet 16 (shown only in Figure 1 for clarity). The heat exchanger 12 is located within a duct 18 defined by an outer wall indicated generally at 20. The entrance 22 to the duct 18 is protected by a grid 24 which prevents larger debris from being drawn into the duct 18. Positioned within the duct 18 is a fan 26 driven by a motor 28 (shown in Figure 1 only) which is operated by a controller 30 (also shown in Figure 1 only), as will be described in further detail shortly.

In use the controller 30 operates the motor 28 to drive the fan 26 in a first direction to draw air through the grid 24 and into the duct 18 via the duct entrance 22. This entrained air is blown across the heat exchanger 12 allowing a transfer of heat from the coolant fluid to the entrained air. Thus, heated air leaves the unit 10 via a duct exit 32 and cooled coolant fluid exits the unit 10 via the heat exchanger outlet 16.

The unit has a first pressure sensor 11 located in the duct between the grid 24 and the fan 26 and a second pressure sensor 13 located in the duct 18 between the fan 26 and the heat exchanger 12 (sensors shown in Figure 1 only). The first and second pressure

sensors 11, 13 are in communication with the controller 30 so that the controller can monitor the pressure P_1 in the duct 18 between the grid 24 and the fan 26 and the pressure P_2 in the duct 18 between the fan 26 and the heat exchanger 12.

5 As described above it is not uncommon for debris to cause the unit 10 to become blocked, particularly when the vehicle is used in off-highway locations. There are two principal locations within the unit 10 which can become blocked. The first of these is described with reference to Figure 2.

10 In Figure 2 the grid 24 has become at least partially blocked by larger debris indicated generally at 34. This is problematic as the flow rate of the air through the grid 34 and thereby across the heat exchanger 12 is reduced which in turn limits the efficiency of the heat exchanger. This can lead to the engine overheating, potentially causing internal damage to the engine.

15

As a result of the grid blockage, the pressure P_1 in the duct 18 between the grid 24 and the fan 26 decreases as does the pressure P_2 in the duct 18 between the fan 26 and the heat exchanger 12. This pressure decrease is detected by the controller 30 and when the pressure P_1 or P_2 reaches a predetermined value the controller 30 reverses the direction of the motor 28. This causes the fan 26 to blow in a reversed, second
20 direction causing the direction of flow of the air within the duct 18 to reverse for a predetermined period of time. This blows the debris 34 from the grid 24. After the predetermined period of time the controller 30 once again switches the direction of the motor 28 to drive the fan in its original, first direction. Normal operation of the unit is
25 thereby resumed.

The second mode of blocking is shown in Figure 3. The heat exchanger 12 (rather than the grid 24 as in Figure 2) has become at least partially blocked by debris indicated generally at 36. This is problematic for the same reasons as set out above in
30 respect of the grid blockage.

As a result of the heat exchanger blockage, there is an increase in the pressure P_2 in the duct 18 between the fan 26 and the heat exchanger 12. When the pressure P_2 reaches a predetermined level the controller generates a warning to the vehicle driver

that the heat exchanger 12 is blocked. This allows the driver to clear the blockage allowing normal operation of the unit to resume.

5 It will be appreciated that it is conceivable that both the grid 24 and heat exchanger 12 could become blocked. In such an eventuality, the controller would reverse the direction of the fan and generate a warning that the heat exchanger 12 is blocked.

10 The cooling unit of the present invention therefore achieves significant advantages over the prior art in that it either clears the blockage or warns the driver of a blockage dependent on the location of the blockage.

CLAIMS

1. A cooling unit for an agricultural vehicle, the cooling unit including:
- 5 a grid for allowing air to enter the unit whilst limiting the ingress of debris into the unit,
- a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger,
- a duct situated between the grid and the heat exchanger,
- a fan situated in the duct, the fan driven by a motor to move air along
- 10 the duct and across the heat exchanger,
- a first pressure sensor for measuring the pressure (p_1) in the duct between the grid and the fan, and/or a second pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger,
- 15 a controller in communication with first and/or second pressure sensor to monitor the pressure p_1 and/or p_2 ,
- wherein the fan is operable by the controller in a first direction to draw air through the grid and across the heat exchanger and in a second direction for a predetermined period of time upon the pressure p_1 falling
- 20 below a first predetermined value and/or the pressure p_2 falling below a second predetermined value.
2. A cooling unit for an agricultural vehicle, the cooling unit including:
- a grid for allowing air to enter the unit whilst limiting the ingress of
- 25 debris into the unit,
- a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger,
- a duct situated between the grid and the heat exchanger,
- a fan situated in the duct, the fan driven by a motor to move air along
- 30 the duct and across the heat exchanger,
- a pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger,
- a controller in communication with the pressure sensor to monitor the pressure p_2 ,

wherein the controller generates a heat exchanger blockage warning in the event that the pressure p_2 rises above a predetermined value.

3. A method of detecting and/or removing debris from the cooling unit of an agricultural vehicle, the cooling unit including:

5

a grid for allowing air to enter the unit whilst limiting the ingress of debris into the unit,

a heat exchanger for transferring heat from a coolant carried within the heat exchanger to air passing across the heat exchanger,

10

a duct situated between the grid and the heat exchanger,

a fan situated in the duct, the fan driven by a motor to move air along the duct and across the heat exchanger,

a pressure sensor for measuring the pressure (p_2) in the duct between the fan and the heat exchanger,

15

a controller in communication with the pressure sensor to monitor the pressure p_2 ,

the method including the steps of:

operating the fan in a first direction to draw air through the grid and across the heat exchanger,

20

operating the fan in a second reversed direction when the pressure p_2 drops below a first predetermined value.

4. The method of claim 3 wherein the method includes the step of generating a heat exchanger blockage warning when the pressure p_2 rises above a second predetermined value.

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5. The method of claim 3 or 4 wherein the unit includes an additional pressure sensor measuring the pressure p_1 in the duct between the grid and the fan, the method including the step of operating the fan in a second reversed direction when the pressure p_1 drops below a third predetermined value.

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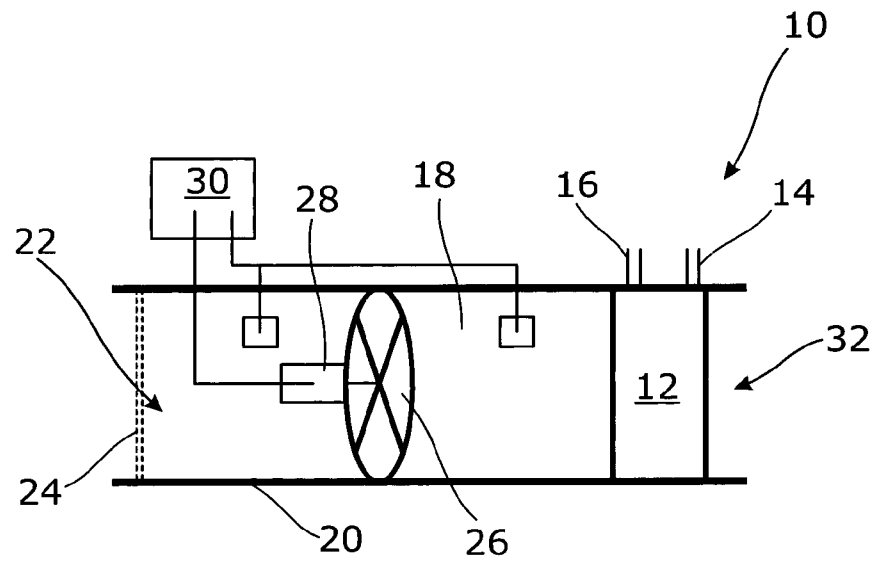


Figure 1

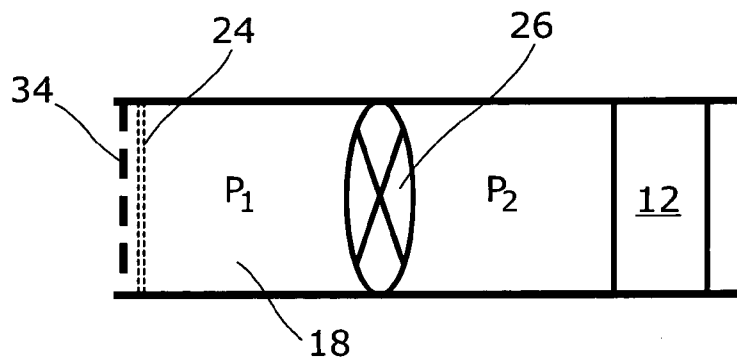


Figure 2

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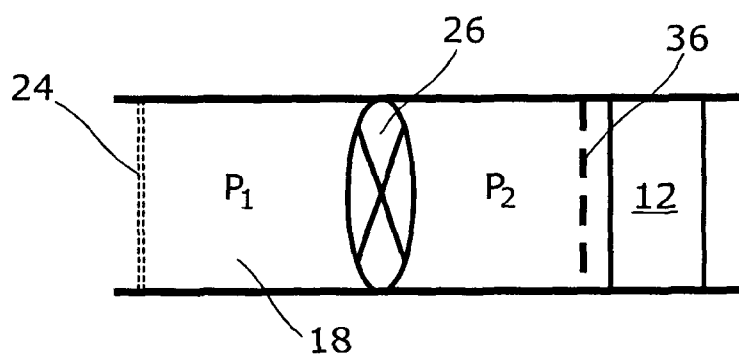


Figure 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F01P5/04 F01P11/12
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)
F01P E02F

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.
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Y	DATABASE WPI Week 201065 Thomson Scientific, London, GB; AN 2010-M57351 XP002722045, -& JP 2010 215199 A (SUMITOMO KENKI KK) 30 September 2010 (2010-09-30) abstract; figure 2 -----	1-5
A	DE 10 2004 059701 A1 (STILL GMBH [DE]) 22 June 2006 (2006-06-22) paragraphs [0018], [0019], [0020] paragraphs [0025] - [0029] ----- -/-	1-5



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

20 March 2014

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/050332

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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