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Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: FORAGE HARVESTERS

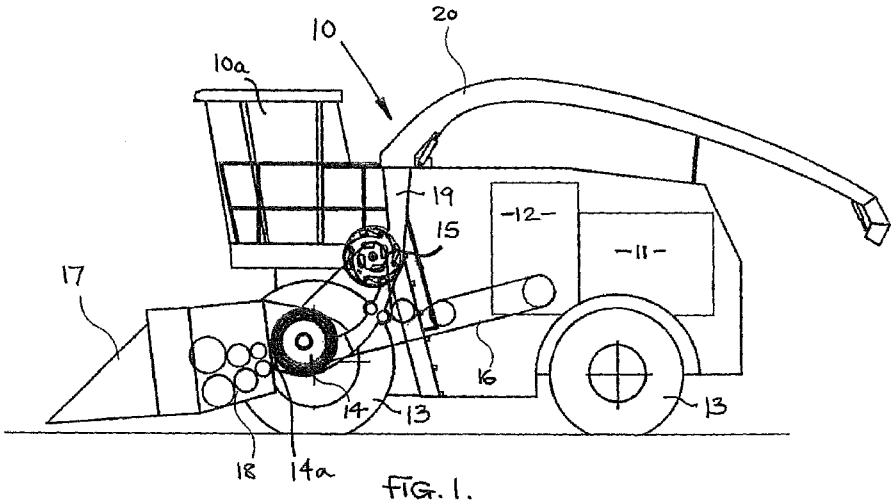

FIG. 1.

(57) Abstract: A braking system for a rotating chopper drum (14) of a forage harvester (10) driven from an engine (11) via a drive train including a disengageable clutch (21). The drive train also drives a first pump (28) connected with the drum (14) which pumps fluid around a hydraulic circuit which includes an openable restriction (40). The system is arranged to brake the chopper drum (14) by disengaging the clutch (21) and arranging the first pump (28) to pump fluid around the circuit via the openable restriction (40) as the drum (14) continues to rotate to convert the energy of the rotating drum (14) into heat.

WO 2011/128286 A1

FORAGE HARVESTERS

This invention relates to self propelled forage harvesters and in particular to a system for braking a chopper drum of a forage harvester when the chopper drum drive is turned off.

Due to the large inertia and high speed of rotation of such chopper drums it can often take 50 seconds or more for the drum to come to rest when the drum drive is turned off and this is dangerous and carries a significant risk of injury.

It is an objective of the present invention to at least reduce the above problem.

Thus in accordance with the present invention there is provided a braking system for a rotating chopper drum of a forage harvester driven from an engine via a drive train including a disengageable clutch, the drive train also driving a first pump connected with the drum which pumps fluid around a hydraulic circuit which includes an openable restriction and a motor driven by the first pump, the motor driving feed rolls of the forage harvester which feed crop to the chopper drum, the system being arranged to brake the chopper drum by disengaging the clutch and arranging the first pump to pump fluid around the circuit via the openable restriction as the drum continues to rotate to convert the energy of the rotating drum into heat, so that when the clutch is disengaged the supply of fluid from the first pump to the feed roll motor is disconnected and the fluid pumped round the circuit by the first pump is diverted through the openable restriction.

It has been found that by using the above braking arrangement the time to brake the drum to rest can be significantly reduced from approaching one minute to less than ten seconds.

In a preferred arrangement the openable restriction comprises a pressure relief valve.

Conveniently the supply of fluid from the first pump to the feed roll motor is disconnected by a solenoid operated two-position dump valve which directs fluid flow from the first pump to a system sump via a restrictor and thus operates a pilot-operated diverter valve to divert the main flow from the first pump through the openable restriction.

When the clutch is disconnected the charge pressure level of the first pump, typically 25bar, will drop below 25bar once the rotational speed of the first pump has dropped below 500 r.p.m. In order to maintain a charge pressure level of 25bar for the first pump at pump speeds of below 500 r.p.m. a second pump driven from the engine can be used.

Conveniently the second pump charge pressure is connected with the first pump charge pressure via a solenoid operated valve.

The system may also include a quick-stop function for the feed roll motor, the quick-stop function including a foreign body detecting device for detecting a foreign body moving in the feed rolls towards the chopper drum, a control unit which when it receives a signal from the detecting device issues a signal to open a second solenoid operated dump valve to open up a connection between the supply side of the first pump and the circuit sump via a second restrictor, reduced pressure on the sump side of the second restrictor then pilot-operating a bypass valve to divert the main supply of fluid from the first pump to a return line of the first pump and also pilot-operating a brake valve which closes the flow of fluid from the feed roll motor down the return line back to the first pump to brake the rotation of the feed roll motor.

The first pump may be driven in reverse to drive the feed rolls backwards and allow the removal of a foreign body from within the feed rolls.

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

Figure 1 shows diagrammatically the layout of a forage harvester which includes a chopper drum braking system in accordance with the present invention;

Figure 2 shows diagrammatically the drive line for the chopper drum and feed rolls of the forage harvester of Figure 1; and

Figure 3 shows the hydraulic supply circuit which powers the feed rolls and operates the chopper drum brake.

Referring to the drawings, Figure 1 shows a forage harvester 10 having a cab 10a and an engine 11 which powers a gearbox 12 from which wheels 13 of the harvester are driven via a hydraulic pump and hydraulic motor closed circuit shown in Figures 2 and 3. Gearbox 12 also drives a chopper drum 14 and discharge fan 15 via a belt drive 16. Crop is fed to the chopper drum 14 via a conventional header 17 and feed rolls 18 which are driven by the drive arrangement shown in Figure 2. The chopper drum has circumferentially spaced blades 14b which cooperate with a fixed cutter bar 14a to cut the crop into short lengths of harvested material.

After the crop is processed by the chopper drum 14 and the associated cutter bar 14a it passes down a discharge chute 19 powered by the fan 15 and into a conventional rotatable discharge spout 20 which feeds the crop into a trailer or other vehicle moving alongside the forage harvester.

The Figure 2 shows the drive train for the chopper drum 14 and the feed rolls 18. Engine 11 drives the chopper drum 14 via a disengageable clutch 21, bevel gears 22 and 23, drive shaft 24 and pulleys 25 and 26 which are connected by a drive belt 27. The drive from engine 11 to chopper drum 14 is thus completely mechanical, but could use a hydraulic link if desired.

The feed rolls 18 are driven by a first variable displacement hydraulic pump 28 driven from shaft 24 which powers a fixed displacement motor 29 via a chopper drum brake control circuit 30 and a feed roll quick-stop control circuit 31. These circuits are shown in greater detail in Figure 3. Motor 29 powers feed rolls 18 via a two speed gearbox 29a and gear trains 32 and 33 respectively.

As is well known, by varying the speed of rotation of feed rolls 18 which in turn varies the speed at which the crop is fed towards the chopper drum which rotates at a substantially constant speed, the length of the chopped crop can be varied. The faster the speed of rotation of the feed rolls the longer the length of the chopped crop.

The combination of the variable displacement pump 28, fixed displacement motor 29 and gearbox 29a allows the speed of rotation of feed rolls 18 to be varied sufficient so that, for example, when harvesting maize a crop length of between 4mms and 10mms can be obtained and when harvesting grass a chopped crop length of up to 20mms can be obtained.

Pumps 34 and 35 are also provided which are driven mechanically from engine 11 via gearbox 12. Pump 34 is connected with hydraulic traction motors (not shown) associated with the wheels of the forage harvester in order to drive the forage harvester over the ground. Pump 35 is a charge pump which can be connected to with the charge circuit of the first pump 28 via a two-position solenoid-operated valve 36 when required. Pump 35 maintains the charge pressure of pump 28 when connected to the charge circuit of pump 28 via valve 36. A further pump 50, which is also driven from shaft 24, powers the header 17.

Referring to Figure 3, the chopper drum brake control circuit 30 includes a solenoid-operated dump valve 37 which is normally closed but when open dumps hydraulic pressure from line A of the circuit of Figure 3 to the sump 38 of the circuit. The chopper drum brake circuit 30 also includes a two-position pilot operated valve 39 and a pressure relief valve 40.

The feed roll quick-stop circuit 31 includes a second solenoid-operated dump valve 41 which when open discharges fluid into the circuit sump 38 and a two-position pilot operated (and also manually operable) diverter valve 42 connected between the output line A and the return line B of pump 28. A further pressure control valve 43 also connects the line A and B and a pilot operated two-position brake valve 44 is provided in return line B. This brake valve 44 either allows flow through line B in both directions or only allows flow from pump 28 down line B when the feed rollers are being operated in reverse.

In accordance with the present invention, the chopper drum brake control function operates as follows.

When the forage harvester operator decides to disconnect drive to the chopper drum 14 he operates the appropriate control provided in the forage harvester cab 10a and this disconnects clutch 21 and also actuates the solenoid 37a of solenoid operated dump valve 37 to connect the supply line A with the system sump 38 and actuates solenoid 36a of the two position valve 36 to connect charge pump 35 with the charge circuit of pump 28 to ensure that the charge pressure of pump 28 is maintained at around 25bar as the speed of pump 28 falls. Due to the presence of restrictor 45, the pressure on the sump side of restrictor 45 falls to sump level which operates the pilot operated valve 39 to disconnect line A from motor 29 and connects line A to line B via the pressure relief valve 40. Disconnection of line A from motor 29 via valve 39 disconnects drive to the feed rolls 18 which is an important safety feature of the present invention since it ensures that the feed rolls cannot restart due to any continued operation of pump 28.

With clutch 21 disconnected pump 28 continues to pump fluid through the pressure relief valve 40 (which is set at a level of approximately 200 bar) converting the energy from the rotating chopper drum 14 and connected pump 28 into heat as the fluid within the circuit of Figure 3 is pumped through the pressure relief valve 40 and back to the pump 28 via return line B.

This produces a high level of braking on the chopper drum 14 which is connected with the pump 28 via shaft 24 and thus the time to brake the rotation of the chopper drum to rest is dramatically reduced from times approximating to one minute to times of 10 seconds or less.

As will be appreciated, in the example described, the operation of the feed roll quick-stop circuit 31 is intimately connected with the operation of the chopper drum brake control circuit 30 since these two circuits are interconnected for convenience. It will be understood that a particular forage harvester could have circuit 30 without circuit 31 or could have circuit 31 without circuit 30.

A foreign body detector 45 is provided adjacent to the feed rolls 18 to detect metal or other foreign bodies which have entered the feed rolls and which will potentially seriously damage the chopper drum were they to reach the drum and associated cutter bar 14a. This detector 45 is connected with an overall control system 46 which controls the operation of chopper drum control circuit 30 and feed roll quick-stop circuit 31 together with solenoid-operated valve 36 as shown diagrammatically in Figure 2. Overall control system 46 also receives command inputs from the operator by one or more input devices shown diagrammatically in Figure 2 at 47.

Thus, when the detector 45 provides a signal to overall control system 46, indicating that a foreign body has entered the feed rolls 18, the control 46 operates the solenoid 41a of dump valve 41 to connect supply line A with the sump 38 via restrictor 47. The pressure on the sump side of restrictor 47 falls to sump level which operates pilot operated valve 42 to divert flow from line A to line B via connection 48. Also the higher level of pressure in line 49 operates pilot operated brake valve 44 to cut off the flow of fluid in line B towards pump 28 and thus maintain the high pressure in return line B between motor 29 and pilot operated brake valve 44 against which the motor connected with feed rolls 18 attempts to rotate. This produces a rapid braking effect on motor 29 which in turn rapidly stops the rotation of the feed rolls 18 before the foreign body can reach the chopper drum 14.

As indicated above, the feed rolls 18 can be driven in reverse to dislodge foreign bodies from within the feed rolls by reversing pump 28 so that line B becomes the supply line to motor 29 and the line A the return line to pump 28. When operating in reverse there is no need for chopper drum brake circuit 30 or quick-stop control circuit 31 to be operative.

Thus the present invention provides a chopper drum braking circuit 30 which can significantly reduce the time to bring the chopper drum to a halt by arranging the pump 28, which normally drives the feed rolls 18 but is connected with the chopper drum 14, to pump fluid at a high pressure through pressure relief valve 40 to convert the energy of the rotating chopper drum into heat.

An interconnected quick-stop feed roll control circuit is also provided.

It will be appreciated that the pump 28 can be arranged to pump fluid through some other form of openable restriction in place of the pressure relief valve 40. For example, the pressure relief valves which are typically installed in the closed circuit pump 28 can be used. Alternatively pressure relief valve 40 could be replaced with a fixed orifice, a variable orifice, a flow control valve, or an electronically adjustable pressure relief valve. As a further alternative, a hydraulic accumulator could be used to store the fluid instead of dumping the fluid to sump 38 so that the hydraulic energy stored in the accumulator can be reused.

Also, the drum braking circuit 30 can be used without the quick-stop circuit 31 and the two circuits can be designed independently and located at different positions on the forage harvester.

CLAIMS

1. A braking system for a rotating chopper drum (14) of a forage harvester (10) driven from an engine (11) via a drive train including a disengageable clutch (21), the drive train also driving a first pump (28) connected with the drum which pumps fluid around a hydraulic circuit which includes an openable restriction (40) and a motor (29) driven by the first pump, the motor driving feed rolls (18) of the forage harvester which feed crop to the chopper drum, the system being arranged to brake the chopper drum (14) by disengaging the clutch (21) and arranging the first pump (28) to pump fluid around the circuit via the openable restriction (40) as the drum continues to rotate to convert the energy of the rotating drum into heat, so that when the clutch (21) is disengaged the supply of fluid from the first pump (28) to the feed roll motor (29) is disconnected and the fluid pumped round the circuit by the first pump is diverted through the openable restriction (40).

2. A system according to claim 1 in which the supply of fluid from the first pump (28) to the feed roll motor is disconnected by a solenoid operated two-position dump valve (37) which directs fluid flow from the first pump to a system sump (38) via a restrictor (45) and thus operates a pilot-operated diverter valve (39) to divert the main flow from the first pump through the openable restriction (40).

3. A system according to claim 1 or 2 in which when the clutch (21) is disconnected the charge pressure level of the first pump (28) is maintained by the charge pressure of a second pump (35) driven from the engine.

4. A system according to claim 3 in which the second pump (35) charge pressure is connected with the first pump (28) charge pressure via a solenoid operated valve (36).

5. A system according to any one of claims 1 to 4 which includes a quick-stop function for the feed roll motor (29), the quick-stop function including a foreign body detecting device (45) for detecting a foreign body moving in the

feed rolls (18) towards the chopper drum (14), a control unit (46) which when it receives a signal from the detecting device (45) issues a signal to open a second solenoid operated dump valve (41) to open up a connection between the supply side A of the first pump (28) and the circuit sump (38) via a second restrictor (47), reduced pressure on the sump side of the second restrictor then pilot-operating a bypass valve (42) to divert the main supply of fluid from the first pump to a return line (B) of the first pump and also pilot-operating a brake valve (44) which closes the flow of fluid from the feed roll motor (29) down the return line (B) back to the first pump (28) to brake the rotation of the feed roll motor (29).

6. A system according to claim 5 in which the first pump (28) can be driven in reverse to drive the feed rolls (18) backwards and allow the removal of a foreign body from within the feed rolls.

7. A system according to any one of claims 1 to 6 in which the openable restriction comprises a pressure relief valve(40).

8. A braking system for a rotating chopper drum of a forage harvester constructed and arranged substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

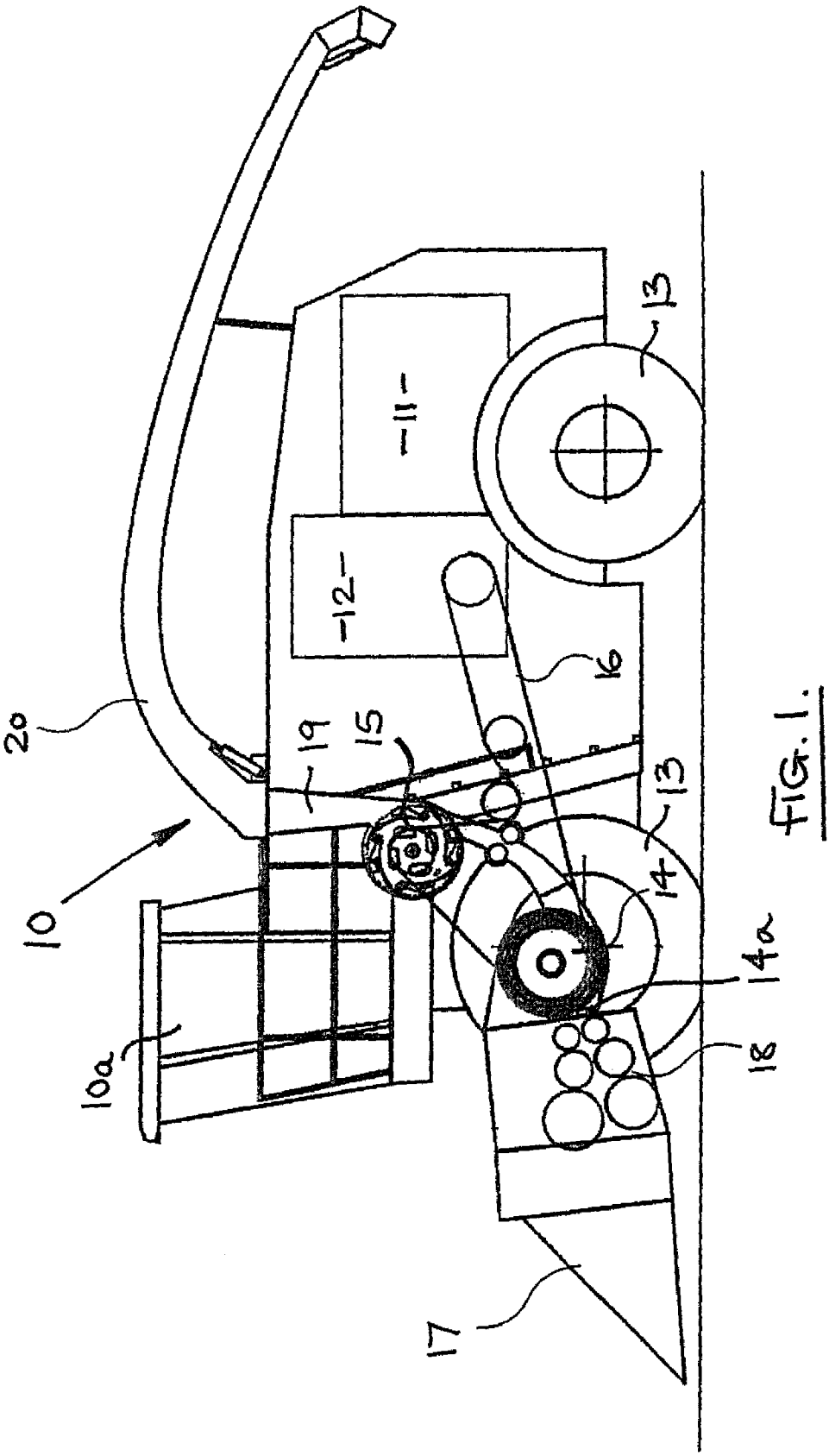

FIG. 1.

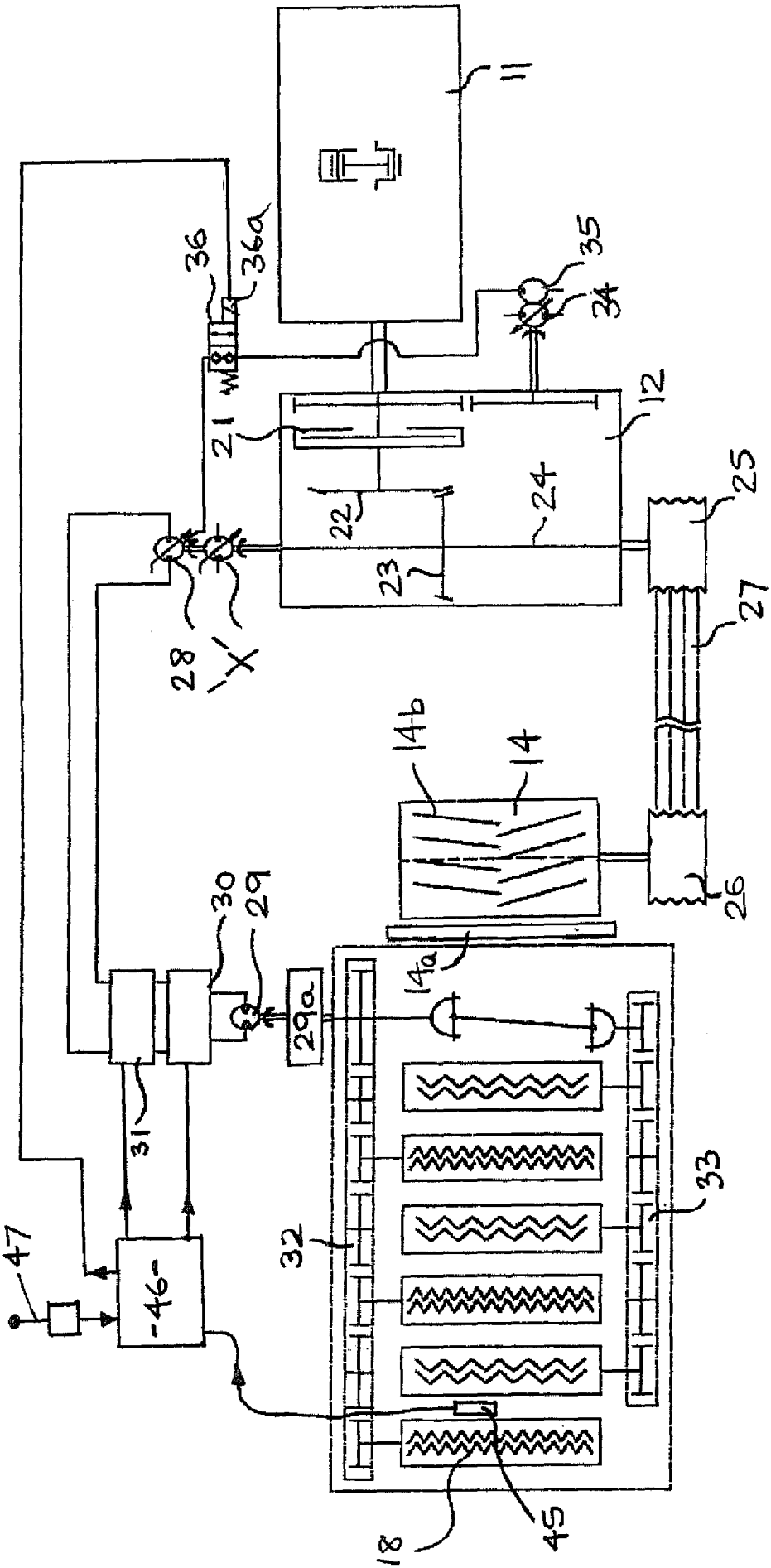
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FIG. 2.

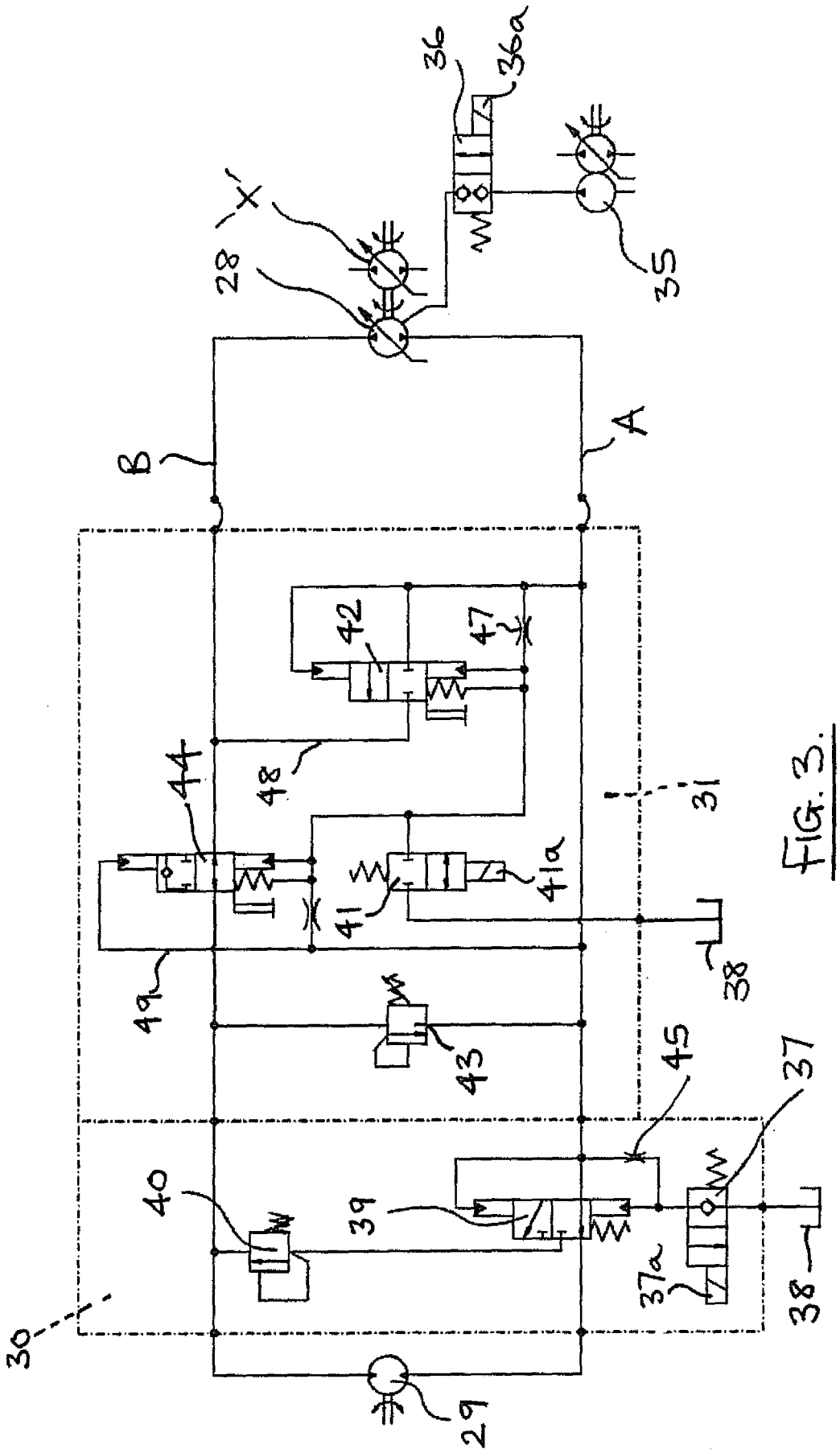
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FIG. 3.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/055609

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01D43/08 A01D75/18
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)
A01D A01F

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/050872 A1 (KEMPF BERND [DE]) 10 March 2005 (2005-03-10) abstract; claims 1-7; figures 1,2 paragraphs [0009], [0012], [0015], [0019] - [0020], [0022] - [0026]	1,5
A	DE 10 2009 002849 A1 (DEERE & CO [US]; BOSCH GMBH ROBERT [DE]) 14 January 2010 (2010-01-14) abstract; claims 1-3; figures 1,2 paragraphs [0007], [0017] - [0019], [0021] - [0023], [0025], [0030], [0032]	1,5-7
A	US 2006/254235 A1 (DUECKINGHAUS HEINZ [DE] ET AL) 16 November 2006 (2006-11-16) abstract; claims 1,2,5-11; figures 1-4 paragraphs [0010] - [0013], [0017], [0033], [0035] - [0036], [0038], [0039], [0043] - [0044]	1,5-7

☐ Further documents are listed in the continuation of Box C.

☒ 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

"E" earlier document but published on or after the international filing date

"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
9 August 2011	18/08/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Guillem Gisbert, I

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2011/055609

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 8
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 8

Claim 8 contains a reference to the description and/or the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/055609

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005050872 A1	10-03-2005	CA 2441251 A1	19-03-2004
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