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United States Patent	12385219
Kind Code	B2
Date of Patent	August 12, 2025
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Shovel

Abstract

A shovel includes an undercarriage, an upper swing structure swingably attached to the undercarriage, and an automatic greaser mounted on the upper swing structure. The automatic greaser is configured to individually change the amount of grease fed to a first greasing point among multiple greasing points and the amount of grease fed to a second greasing point among the multiple greasing points based on information on the multiple greasing points.

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Appl. No.: **17/034554**

Filed: **September 28, 2020**

Prior Publication Data

Document Identifier	Publication Date
US 20210025134 A1	Jan. 28, 2021

Foreign Application Priority Data

JP	2018-070027	Mar. 30, 2018

Related U.S. Application Data

continuation parent-doc WO PCT/JP2019/013787 20190328 PENDING child-doc US 17034554

Publication Classification

Int. Cl.: **E02F9/20** (20060101); **E02F9/08** (20060101); **F16N7/14** (20060101); **F16N27/02** (20060101); **F16N29/02** (20060101)

U.S. Cl.:

CPC **E02F9/2025** (20130101); **E02F9/0875** (20130101); **F16N7/14** (20130101); **F16N27/02** (20130101); **F16N29/02** (20130101);

Field of Classification Search

CPC: E02F (9/0875); E02F (9/2025); F16N (7/14); F16N (27/02); F16N (29/02)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation application filed under 35 U.S.C. 111(a) claiming benefit under 35 U.S.C. 120 and 365(c) of PCT International Application No. PCT/JP2019/013787, filed on Mar. 28, 2019 and designating the U.S., which claims priority to Japanese patent application No. 2018-070027, filed on Mar. 30, 2018. The entire contents of the foregoing applications are incorporated herein by reference.

BACKGROUND
Technical Field
(1) The present invention relates to shovels with an automatic greasing device.
Description of Related Art
(2) A shovel with an automatic greaser has been known. This automatic greaser is configured to feed grease to pin linking members placed between the swing frame of an upper swing structure and a boom, between the boom and an arm, between the arm and a bucket, on each end side of a boom cylinder, on each end side of an arm cylinder, on each end side of a bucket cylinder and so on. FurtheLmore, the automatic greaser is configured to, when any of the load pressure of the boom cylinder, the load pressure of the arm cylinder, and the load pressure of the bucket cylinder exceeds a reference pressure, increase the supply of grease according as the load pressure increases.
SUMMARY
(3) According to an aspect of the present invention, a shovel includes an undercarriage, an upper swing structure swingably attached to the undercarriage, and an automatic greaser mounted on the upper swing structure. The automatic greaser is configured to individually change the amount of grease fed to a first greasing point among multiple greasing points and the amount of grease fed to a second greasing point among the multiple greasing points based on information on the multiple greasing points.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1**A is a side view of a shovel according to an embodiment of the present invention;
(2) FIG. **1**B is a diagram illustrating a structure around a rod-side link pin as viewed from below;
(3) FIG. **2** is a diagram illustrating an example configuration of a basic system installed in the shovel of FIG. **1**A;
(4) FIG. **3** is a diagram illustrating an example configuration of a distributor;
(5) FIG. **4** is a flowchart of a greasing process;
(6) FIG. **5** is a flowchart of an example of a distribution ratio changing process;
(7) FIG. **6** illustrates changes in the ratio in which grease is distributed among greasing points;
(8) FIG. **7** is a flowchart of another example of the distribution ratio changing process;
(9) FIG. **8** illustrates changes in the ratio in which grease is distributed among greasing points;
(10) FIG. **9** is a diagram illustrating another example configuration of the distributor; and
(11) FIG. **10** is a schematic diagram illustrating an example configuration of a shovel management system.
DETAILED DESCRIPTION
(12) The related-art automatic greaser, however, is configured to, when any of the load pressure of the boom cylinder, the load pressure of the arm cylinder, and the load pressure of the bucket

cylinder exceeds a reference pressure, increase the supply of grease to all pin linking members. Therefore, the supply of grease to pin linking members with low friction as well is increased.
(13) Therefore, it is desired to provide a shovel that can feed grease more appropriately.
(14) According to an aspect of the present invention, a shovel that can feed grease more appropriately is provided.
(15) FIG. **1**A is a side view of a shovel according to an embodiment of the present invention. An upper swing structure **3** is swingably mounted on an undercarriage **1** of the shovel via a swing mechanism **2** serving as a work element. A boom **4** serving as a work element is attached to the upper swing structure **3**. An arm **5** serving as a work element is attached to the distal end of the boom **4**. A bucket **6** serving as a work element is attached to the distal end of the arm **5**. The boom **4**, the arm **5**, and the bucket **6** constitute an excavation attachment serving as an example of an attachment, and are hydraulically driven by a boom cylinder **7**, an arm cylinder **8**, and a bucket cylinder **9**, respectively.
(16) A cabin **10** serving as a cab, an engine **11** serving as a drive source, an automatic greaser **50**, etc., are mounted on the upper swing structure **3**.
(17) The automatic greaser **50** automatically feeds a lubricant such as grease to multiple greasing points. According to this embodiment, the greasing points include a ring GP**1** of the swing mechanism **2**, a boom foot pin GP**2**, an arm foot pin GP**3**, an arm top pin GP**4**, a bottom-side link pin GP**5** and a rod-side link pin GP**6** of the boom cylinder **7**, a bottom-side link pin GP**7** and a rod-side link pin GP**8** of the arm cylinder **8**, a bottom-side link pin GP**9** and a rod-side link pin GP**10** of the bucket cylinder **9**, an arm-side link pin GP**11** of a first bucket link **6**A, and a bucket-side link pin GP**12** of a second bucket link **6**B. Furthermore, according to this embodiment, as illustrated in FIG. **1**B, the greasing points for the rod-side link pin GP**10** include three points: a right side GP**10**-LK of the rod-side link pin GP**10** in the second bucket link **6**B, a left side GP**10**-LK of the rod-side link pin GP**10** in the second bucket link **6**B, and a center GP**10**-CY of the rod-side link pin GP**10** of the bucket cylinder **9**. FIG. **1**B illustrates a structure around the rod-side link pin GP**10** as viewed from below.
(18) Next, an example configuration of a basic system installed in the shovel of FIG. **1**A is described with reference to FIG. **2**. FIG. **2** illustrates an example configuration of the basic system. The basic system is constituted mainly of a controller **30**, a display device **40**, the automatic greaser **50**, etc.
(19) The controller **30** is a control device that controls various devices installed in the shovel. The controller **30** is composed of a processing unit including a CPU and an internal memory. The CPU executes programs stored in the internal memory to implement various functions of the controller **30**.
(20) The display device **40** displays a screen including various kinds of information in response to a command from the controller **30**. The display device **40** is, for example, a liquid crystal display connected to the controller **30**. The display device **40** is connected to the controller **30** via, for example, a communication network such as a CAN, a dedicated line, or the like. According to this embodiment, the display device **40** includes an image display part **41** and a switch panel **42**. The switch panel **42** is a switch panel including various hardware switches.
(21) The controller **30**, the display device **40**, the automatic greaser **50**, etc., are supplied with electric power from a rechargeable battery **70** to operate. The rechargeable battery **70** is charged by a generator **11***a* driven by the engine **11**. The electric power of the rechargeable battery **70** is also supplied to electrical equipment **72**, a starter **11***b* of the engine **11**, etc. The starter **11***b* is driven with electric power from the rechargeable battery **70** to start the engine **11**.
(22) The engine **11** is connected to a main pump **14** and a pilot pump **15** and controlled by an engine control unit (ECU) **74**. The ECU **74** transmits various data indicating the condition of the engine **11** to the controller **30**. The various data include, for example, data indicating coolant water temperature detected with a water temperature sensor **11***c*. The controller **30** stores these data in the

internal memory and can display the data on the display device **40** at an appropriate time.
(23) The main pump **14** supplies hydraulic oil to a control valve **17** via a hydraulic oil line. According to this embodiment, the main pump **14** is a swash plate variable displacement hydraulic pump, and the discharge flow rate is controlled by a regulator **14***a*. The regulator **14***a*, for example, increases or decreases the discharge flow rate of the main pump **14** in response to a command from the controller **30**. The regulator **14***a* transmits data indicating a swash plate tilt angle to the controller **30**. A discharge pressure sensor **14***b* transmits data indicating the discharge pressure of the main pump **14** to the controller **30**. An oil temperature sensor **14***c* provided in a conduit between the main pump **14** and a tank storing hydraulic oil that the main pump **14** draws in transmits data representing the temperature of hydraulic oil flowing through the conduit to the controller **30**.
(24) The pilot pump **15** supplies hydraulic oil to various hydraulic control apparatus via a pilot line. The pilot pump **15** is, for example, a fixed displacement hydraulic pump.
(25) The control valve **17** is a hydraulic controller that controls a hydraulic system installed in the shovel. The control valve **17** selectively supplies hydraulic oil discharged by the main pump **14** to, for example, a left travel hydraulic motor **1**L, a right travel hydraulic motor **1**R, a swing hydraulic motor **2**A, the boom cylinder **7**, the arm cylinder **8**, the bucket cylinder **9**, and the like (hereinafter collectively referred to as “hydraulic actuators”).
(26) An operating device **26** is used to operate the hydraulic actuators. According to this embodiment, the operating device **26** includes a left operating lever **26**L, a right operating lever **26**R, and a travel lever **26**C. When the operating device **26** is operated, hydraulic oil is supplied from the pilot pump **15** to a pilot port of a flow control valve for a corresponding hydraulic actuator. Each pilot port is supplied with hydraulic oil of a pressure (pilot pressure) commensurate with the operation details (direction of operation and amount of operation) of the corresponding operating device **26**.
(27) An operating pressure sensor **29** detects a pilot pressure when the operating device **26** is operated, and transmits data indicating the detected pilot pressure to the controller **30**. The controller **30** detects the operation details of the operating device **26** from the pilot pressure detected by the operating pressure sensor **29**.
(28) Next, functional elements of the controller **30** are described. The controller **30** includes a time obtaining part **30***a*, a greasing information obtaining part **30***b*, and a greasing control part **30***c* as functional elements.
(29) The time obtaining part **30***a* is a functional element that obtains an elapsed time between two time points. According to this embodiment, the time obtaining part **30***a* can process a time exceeding 24 hours. The time obtaining part **30***a*, for example, obtains an elapsed time between a first time point and a second time point based on a GPS signal (time information including a week number) received via a GPS receiver at each of the first time point and the second time point. In this case, the time obtaining part **30***a* may derive the number of days elapsed between the first time point and the second time point. The time obtaining part **30***a* may receive signals from another device with at least one of a calendar function, a date managing function, etc., and derive an elapsed time (that may exceed 24 hours) between the first time point and the second time point.
(30) The greasing information obtaining part **30***b* is a functional element that obtains information on multiple greasing points. According to this embodiment, the greasing information obtaining part **30***b* obtains information on multiple greasing points based on the outputs of an information obtaining device **73**, an engine rotational speed adjustment dial **75**, etc.
(31) The information on multiple greasing points is at least one of information on the operating condition of multiple greasing points, information on the work environment of multiple greasing points, etc.
(32) The infonuation obtaining device **73** detects information on the shovel. According to this embodiment, the information obtaining device **73** includes at least one of angle sensors (a boom

angle sensor, an arm angle sensor, and a bucket angle sensor), a body tilt sensor, a swing angular velocity sensor, cylinder pressure sensors (a boom rod pressure sensor, a boom bottom pressure sensor, an arm rod pressure sensor, an arm bottom pressure sensor, a bucket rod pressure sensor, and a bucket bottom pressure sensor), cylinder stroke sensors (a boom cylinder stroke sensor, an arm cylinder stroke sensor, and a bucket cylinder stroke sensor), the discharge pressure sensor **14***b*, and the operating pressure sensor **29**. The information obtaining device **73**, for example, obtains, as shovel-related information, at least one of a boom angle, an arm angle, a bucket angle, a body tilt angle, a swing angular velocity, a boom rod pressure, a boom bottom pressure, an arm rod pressure, an arm bottom pressure, a bucket rod pressure, a bucket bottom pressure, a boom stroke amount, an arm stroke amount, a bucket stroke amount, the discharge pressure of the main pump **14**, and the operating pressure of the operating device **26**. The angle sensors may be constituted of a combination of an acceleration sensor and a gyroscope.

(33) The information obtaining device **73** may include at least one of image sensors (for example, a monocular camera, a stereo camera, a thermographic sensor, and a distance image sensor) and distance sensors (for example, a laser range finder, a laser radar, a millimeter wave sensor, and an ultrasonic sensor).

(34) The engine rotational speed adjustment dial **75** is a dial for adjusting the rotational speed of the engine **11**, and, for example, can switch the engine rotational speed in a stepwise manner. According to this embodiment, the engine rotational speed adjustment dial **75** is so configured as to be able to select the engine rotational speed from among the four levels of SP mode, H mode, A mode, and idling mode. The engine rotational speed adjustment dial **75** transmits data indicating the setting of the engine rotational speed to the controller **30**. FIG. **2** illustrates that the H-mode is selected by the engine rotational speed adjustment dial **75**.

(35) The SP mode is an engine mode selected when it is desired to prioritize workload, and uses the highest engine rotational speed. The H mode is an engine mode selected when it is desired to balance workload and fuel efficiency, and uses the second highest engine rotational speed. The A mode is an engine mode selected when it is desired to operate the shovel at low noise while prioritizing fuel efficiency, and uses the third highest engine rotational speed. The idling mode is an engine mode selected when it is desired to idle the engine **11**, and uses the lowest engine rotational speed. The engine **11** is controlled to a constant rotational speed at the engine rotational speed of the rotational speed mode set by the engine rotational speed adjustment dial **75**.

(36) The greasing information obtaining part **30***b*, for example, determines the operating condition of multiple greasing points based on the respective movements of the boom **4**, the arm **5**, and the bucket **6**. The respective movements of the boom **4**, the arm **5**, and the bucket **6** are, for example, detected based on the output of at least one of cylinder pressure sensors, operating pressure sensors, angle sensors, and cylinder stroke sensors.

(37) The greasing information obtaining part **30***b*, for example, may determine the work environment of multiple greasing points based on the output of at least one of image sensors and distance sensors. The work environment is, for example, at least one of a work environment where a foreign object (water, mud, dust or the like) is likely to be mixed in a lubricant, a work environment where a lubricant is likely to dry, a work environment where a lubricant is likely to degrade, etc.

(38) The greasing control part **30***c* is a functional element that controls the automatic greaser **50**. According to this embodiment, the greasing control part **30***c* controls at least one of timing to start greasing by the automatic greaser **50**, timing to end the greasing, etc., based on the outputs of the time obtaining part **30***a*, the greasing information obtaining part **30***b*, etc. The greasing control part **30***c* may select a greasing point and may change the ratio in which a lubricant is distributed among the greasing points on an as-needed basis. An operator, for example, may check the distribution ratio displayed on the display device **40** and then change the distribution ratio.

(39) The automatic greaser **50** is constituted mainly of a grease pump **51**, a grease tank **52**, a

solenoid valve **53**, a distributor **54**, etc.

(40) The grease pump **51** is an example of a lubricant pump and pumps grease from the grease tank **52** to the distributor **54** via the solenoid valve **53**. According to this embodiment, the grease pump **51** is an electric plunger pump of a fixed discharge quantity type with a piston and a cylinder. The grease pump **51**, however, may alternatively be of a variable discharge quantity type. The piston is reciprocated by a cam mechanism driven by an electric motor. The controller **30** controls the electric motor to control the discharge of grease by the grease pump **51**. The grease pump **51** may be a pump of another drive system such as a hydraulic system, a pneumatic system, or the like.

(41) The grease tank **52** is a container for containing grease. According to this embodiment, the grease tank **52** is a container that accommodates a grease cartridge urged in a compression direction by a spring. Another container such as a pail may be used.

(42) The solenoid valve **53** operates in response to a control command from the controller **30**. According to this embodiment, the solenoid valve **53** is a selector valve with one inlet port and three outlet ports. The inlet port is connected to the discharge port of the grease pump **51**. Each of the three outlet ports is connected to the distributor **54**.

(43) The distributor **54** is a device that distributes the grease pumped by the grease pump **51** to the greasing points. According to this embodiment, the distributor **54** includes a first distributor **54-1**, a second distributor **54-2**, and a third distributor **54-3**.

(44) The controller **30** switches the valve position of the solenoid valve **53** so that grease is pumped to one of the first distributor **54-1**, the second distributor **54-2**, and the third distributor **54-3**. The controller **30** may also cause grease to be pumped to at least one of the first distributor **54-1**, the second distributor **54-2**, and the third distributor **54-3**. The solenoid valve **53** has, for example, a first valve position that causes the inlet port to communicate with a first outlet port, a second valve position that causes the inlet port to communicate with a second outlet port, a third valve position that causes the inlet port to communicate with a third outlet port, and a fourth valve position that closes all the three outlet ports.

(45) FIG. **3** illustrates an example configuration of the distributor **54**. As illustrated in FIG. **3**, the distributor **54** includes the first distributor **54-1**, the second distributor **54-2**, and the third distributor **54-3**.

(46) According to the example of FIG. **3**, the first distributor **54-1** has one inlet port and seven outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to the first outlet port of the solenoid valve **53**. The hoses extending from the seven outlet ports are connected to discharge ports placed at greasing points associated with the bucket **6**. The first distributor **54-1** is configured to discharge the same amount of grease as received at the inlet port from each of the seven outlet ports in sequential order.

(47) The second distributor **54-2** has one inlet port and three outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to the second outlet port of the solenoid valve **53**. The hoses extending from the three outlet ports are connected to discharge ports placed at greasing points associated with the arm **5**. The second distributor **54-2** is configured to discharge the same amount of grease as received at the inlet port from each of the three outlet ports in sequential order.

(48) The third distributor **54-3** has one inlet port and nine outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to the third outlet port of the solenoid valve **53**. The hoses extending from the nine outlet ports are connected to discharge ports placed at greasing points associated with the swing mechanism **2** and the boom **4**. The third distributor **54-3** is configured to discharge the same amount of grease as received at the inlet port from each of the nine outlet ports in sequential order.

(49) According to this configuration, the distributor **54** of FIG. **3** can feed grease to up to 19 greasing points. In FIG. **3**, #**1**, #**2** . . . #**19** denote 19 greasing points. At least two of the **19** greasing points may be the same greasing point.

(50) Table 1 illustrates an example of the correspondence relationship between greasing numbers and greasing points. According to this embodiment, as described above, greasing numbers #**1** through #**7** associated with the first distributor **54-1** are correlated with the discharge ports placed at the greasing points associated with the bucket **6**, greasing numbers #**8** through #**10** associated with the second distributor **54-2** are correlated with the discharge ports placed at the greasing points associated with the arm **5**, and greasing numbers #**11** through #**19** associated with the third distributor **54-3** are correlated with the discharge ports placed at the greasing points associated with the swing mechanism **2** and the boom **4**. The number of greasing points associated with the bucket-side link pin GP**12** corresponding to greasing number #**1** is one for standard shovels, but is two for crane shovels.
(51) TABLE-US-00001 TABLE 1 Greasing Number Greasing Point #1 BUCKET-SIDE LINK PIN GP12 OF SECOND BUCKET LINK 6B #2 ARM-SIDE LINK PIN GP11 OF FIRST BUCKET LINK 6A #3 RIGHT SIDE GP10-LK OF ROD-SIDE LINK PIN GP10 OF SECOND BUCKET LINK 6B #4 LEFT SIDE GP10-LK OF ROD-SIDE LINK PIN GP10 OF SECOND BUCKET LINK 6B #5 BOTTOM-SIDE LINK PIN GP9 OF BUCKET CYLINDER 9 #6 CENTER GP10-CY OF ROD-SIDE LINK PIN GP10 OF BUCKET CYLINDER 9 #7 ARM TOP PIN GP4 #8 ARM FOOT PIN GP3 #9 BOTTOM-SIDE LINK PIN GP7 OF ARM CYLINDER 8 #10 ROD-SIDE LINK PIN GP8 OF ARM CYLINDER 8 #11 RIGHT SIDE OF BOOM FOOT PIN GP2 #12 LEFT SIDE OF BOOM FOOT PIN GP2 #13 RIGHT SIDE OF BOTTOM-SIDE LINK PIN GP5 OF BOOM CYLINDER 7 #14 LEFT SIDE OF BOTTOM-SIDE LINK PIN GP5 OF BOOM CYLINDER 7 #15 RIGHT SIDE OF ROD-SIDE LINK PIN GP6 OF BOOM CYLINDER 7 #16 LEFT SIDE OF ROD-SIDE LINK PIN GP6 OF BOOM CYLINDER 7 #17 FRONT SIDE OF RING GP1 OF SWING MECHANISM 2 #18 REAR SIDE OF RING GP1 OF SWING MECHANISM 2 #19 PINION GEAR OF SWING HYDRAULIC MOTOR 2A
(52) Next, a process of the greasing control part **30***c* starting or stopping greasing by the automatic greaser **50** (hereinafter "greasing process") is described with reference to FIG. **4**. FIG. **4** is a flowchart of the greasing process. The greasing control part **30***c*, for example, repeatedly executes this greasing process at predetermined control intervals while the controller **30** is being activated.
(53) When the greasing process is started with the activation of the controller **30**, first, the greasing control part **30***c* determines whether greasing is in progress (step ST**1**). According to this embodiment, the greasing control part **30***c* refers to the value of a greasing flag stored in the internal memory, and determines whether greasing is in progress. The greasing control part **30***c*, for example, sets the value of the greasing flag to "1" (a value indicating that "greasing is in progress") when outputting a greasing start command to the automatic greaser **50**, and sets the value of the greasing flag to "0" (a value indicating that "greasing is not in progress") when outputting a greasing stop command to the automatic greaser **50**. The greasing control part **30***c* may receive the output signal of the automatic greaser **50** to determine whether greasing is in progress.
(54) In response to determining that greasing is not in progress (NO at step ST**1**), the greasing control part **30***c* determines whether a non-greasing time has reached a first set time (step ST**2**). The "non-greasing time" means the duration of non-greasing state in which no greasing is performed by the automatic greaser **50**. For example, the greasing control part **30***c* starts measuring the non-greasing time when outputting a greasing stop command to the automatic greaser **50**. The greasing control part **30***c* monitors the duration of the non-greasing state based on the time elapsed since the output of the greasing stop command obtained by the time obtaining part **30***a*. The first set time serving as settings information is a target time for continuing the non-greasing state, and is, for example, 30 minutes. Hereinafter, the first set time is also referred to as greasing interval.
(55) In response to determining that the non-greasing time has reached the first set time (YES at step ST**2**), the greasing control part **30***c* starts greasing by the automatic greaser **50** (step ST**3**). The greasing control part **30***c*, for example, outputs a greasing start command to the automatic greaser **50**. Specifically, the greasing control part **30***c* outputs a drive start command to the grease pump **51**,

and outputs a valve control command to the solenoid valve **53**. The valve control command to the solenoid valve **53** is, for example, a command for implementing a desired valve position. In this case, the greasing start command means a combination of the drive start command and the valve control command.

(56) In response to determining that the non-greasing time has not reached the first set time (NO at step ST**2**), the greasing control part **30***c* ends the greasing process of this time without starting greasing by the automatic greaser **50**.

(57) In response to determining at step ST**1** that greasing is in progress (YES at step ST**1**), the greasing control part **30***c* determines whether a greasing time has reached a second set time (step ST**4**). The “greasing time” means the duration of greasing state in which greasing is performed by the automatic greaser **50**. The greasing control part **30***c*, for example, starts measuring the greasing time when outputting a greasing start command to the automatic greaser **50**. The greasing control part **30***c* monitors the duration of the greasing state based on the time elapsed since the output of the greasing start command obtained by the time obtaining part **30***a*. The second set time serving as settings information is a target time for continuing the greasing state, and is, for example, 5 minutes (300 seconds).

(58) According to this embodiment, the greasing control part **30***c* controls the automatic greaser **50** such that grease is pumped from the grease pump **51** to the first distributor **54-1** for 50% of the second set time, grease is pumped from the grease pump **51** to the second distributor **54-2** for 20% of the second set time, and grease is pumped from the grease pump **51** to the third distributor **54-3** for 30% of the second set time. Hereinafter, the distribution ratio achieved by this control is represented as “distribution ratio 50:20:30.” Specifically, of the second set time (300 seconds), 50% (150 seconds) is allotted for feeding grease to the first distributor **54-1**, 20% (60 seconds) is allotted for feeding grease to the second distributor **54-2**, and 30% (90 seconds) is allotted for feeding grease to the third distributor **54-3**. The feeding of grease to the first distributor **54-1** is typically performed for 150 consecutive seconds, but may also be performed in three separate times each for 50 seconds, for example. That is, the time of feeding grease to the first distributor **54-1** is satisfactory as long as it is 150 seconds in total. The same is the case with the time of feeding grease to the second distributor **54-2** and the third distributor **54-3**.

(59) In response to determining that the greasing time has reached the second set time (YES at step ST**4**), the greasing control part **30***c* stops greasing by the automatic greaser **50** (step ST**5**). The greasing control part **30***c*, for example, outputs a greasing stop command to the automatic greaser **50**. Specifically, the greasing control part **30***c* outputs a drive stop command to the grease pump **51**, and outputs a valve control command to the solenoid valve **53**. The valve control command to the solenoid valve **53** is, for example, a command for implementing the fourth valve position that closes all the outlet ports. In this case, the greasing stop command means a combination of the drive stop command and the valve control command.

(60) In response to determining that the greasing time has not reached the second set time (NO at step ST**4**), the greasing control part **30***c* ends the greasing process of this time without stopping greasing by the automatic greaser **50**.

(61) According to the above-described configuration, the greasing control part **30***c* can alternately achieve the non-greasing state that continues for the first set time and the greasing state that continues for the second set time. That is, when the elapsed time since ending greasing reaches a predetermined time, the next greasing is started. This elapsed time basically does not include an elapsed time during which the engine **11** is stopped. The elapsed time, however, may include an elapsed time during which the engine **11** is stopped.

(62) Next, an example of a process of the greasing control part **30***c* changing the ratio in which grease is distributed among greasing points (hereinafter “distribution ratio changing process”) is described with reference to FIG. **5**. FIG. **5** is a flowchart of an example of the distribution ratio changing process. The greasing control part **30***c*, for example, executes this distribution ratio

changing process when starting greasing by the automatic greaser **50**.
(63) First, the greasing control part **30***c* of the controller **30** determines whether the work load of a particular part is high (step ST**11**). The particular part is, for example, at least one of a boom-related part, an arm-related part, a bucket-related part, a swing mechanism-related part, etc. The work load is an example of operating condition information, and according to this embodiment, is expressed as being high or not high. According to this embodiment, the bucket-related part is a part related to the greasing points greased through the first distributor **54-1**. The arm-related part is a part related to the greasing points greased through the second distributor **54-2**. The boom-related part and the swing mechanism-related part are parts related to the greasing points greased through the third distributor **54-3**.
(64) According to this embodiment, the greasing control part **30***c* determines whether the work load of a particular part is high, referring to the value of a high load flag stored in the internal memory. The high load flag may include multiple high load flags corresponding to the individual particular parts, such as a boom high load flag, an arm high load flag, a bucket high load flag, and a swing high load flag or may be a single high load flag representing whether the work load of any of the particular parts is high.
(65) In response to determining that the work load of a particular part is high, the controller **30** sets the value of the high load flag to “1.” Specifically, the controller **30**, for example, determines whether the work load of a particular part is high during the latest non-greasing time based on the output of the information obtaining device **73**. For example, the greasing control part **30***c* determines that the work load of the boom-related part is high and sets the value of the boom high load flag to “1” in response to determining that the total operation time of a boom operating lever during the non-greasing time is more than or equal to a predetermined value based on the output of the operating pressure sensor **29**.
(66) The controller **30**, for example, may also determine that the work load of the boom-related part is high and set the value of the boom high load flag to “1” in response to determining that the total amount of movement of the boom **4** during the non-greasing time is more than or equal to a predetermined value based on the output of the boom angle sensor. The total amount of movement of the boom **4** is, for example, the sum of the total amount of upward movement and the total amount of downward movement, and may be expressed as a rotation angle.
(67) The controller **30**, for example, may also determine that the work load of the boom-related part is high and set the value of the boom high load flag to “1” in response to determining that the total amount of extension and retraction (the sum of the total amount of extension and the total amount of retraction) of the boom cylinder **7** during the non-greasing time is more than or equal to a predetermined value based on the output of the boom cylinder stroke sensor.
(68) The controller **30**, for example, may also determine that the work load of the boom-related part is high and set the value of the boom high load flag to “1” in response to determining that the cumulative value of a pin surface pressure acting on the boom foot pin during the non-greasing time is more than or equal to a predetermined value based on the output of the boom bottom pressure sensor.
(69) The controller **30**, for example, may also determine that the work load of the boom-related part is high and set the value of the boom high load flag to “1” in response to determining that the cumulative value of a PV value related to the boom foot pin during the non-greasing time is more than or equal to a predetermined value based on the outputs of the boom angle sensor and the boom bottom pressure sensor. The PV value is expressed as a product of a pin surface pressure acting on the boom foot pin and the total amount of movement of the boom **4**.
(70) The controller **30**, for example, may also determine that the work load of the bucket-related part is high and set the value of the bucket high load flag to “1” in response to determining that the work environment is likely to allow mixture of a foreign object (such as water, mud or dust) into the bucket-related part based on an image of a target of work (such as the ground) output by an

image sensor attached to the upper swing structure **3**.

(71) The controller **30**, for example, may also determine that the work load of the boom-related part is high and set the value of the boom high load flag to "1" in response to determining that the temperature of the boom foot pin is more than or equal to a predetermined value based on a thermal image output by a thermographic sensor attached to the upper swing structure **3**.

(72) The controller **30**, for example, may also determine that the work load of the bucket-related part is high and set the value of the bucket high load flag to "1" in response to determining that the bucket **6** is roughly operated, for example, the bucket **6** is slammed on the ground, that is, in response to determining that the bucket **6** is roughly handled, during the non-greasing time, based on the output of an acceleration sensor attached to the bucket **6**.

(73) In response to determining that the work load of a particular part is high (YES at step ST**11**), the greasing control part **30***c* of the controller **30** changes the ratio in which grease is distributed among greasing points (step ST**12**).

(74) For example, the greasing control part **30***c* changes the ratio in which grease is distributed among greasing points if the value of any of the high load flags is "1." The greasing control part **30***c* changes the ratio in which grease is distributed among greasing points by changing grease distribution time for each of the three distributors **54** without changing the first set time that is a target time for continuing non-greasing state and the second set time that is a target time for continuing greasing state.

(75) For example, in response to determining that the work load of the bucket-related part is high, the greasing control part **30***c* changes the initial distribution ratio 50:20:30 to the distribution ratio 75:5:20. That is, the greasing control part **30***c* changes the setting in which grease is pumped from the grease pump **51** to the first distributor **54-1** for 50% of the second set time to the setting in which grease is pumped from the grease pump **51** to the first distributor **54-1** for 75% of the second set time. Meanwhile, the greasing control part **30***c* changes the setting in which grease is pumped from the grease pump **51** to the second distributor **54-2** for 20% of the second set time to the setting in which grease is pumped from the grease pump **51** to the second distributor **54-2** for 5% of the second set time. Furthermore, the greasing control part **30***c* changes the setting in which grease is pumped from the grease pump **51** to the third distributor **54-3** for 30% of the second set time to the setting in which grease is pumped from the grease pump **51** to the third distributor **54-3** for 20% of the second set time.

(76) Specifically, the setting in which, of the second set time (300 seconds), 150 seconds are allotted for feeding grease to the first distributor **54-1**, 60 seconds are allotted for feeding grease to the second distributor **54-2**, and 90 seconds are allotted for feeding grease to the third distributor **54-3** is changed to the setting in which, of the second set time (300 seconds), 225 seconds are allotted for feeding grease to the first distributor **54-1**, 15 seconds are allotted for feeding grease to the second distributor **54-2**, and 60 seconds are allotted for feeding grease to the third distributor **54-3**.

(77) The greasing control part **30***c*, however, may increase or decrease at least one of the first set time and the second set time and then change the ratio in which grease is distributed among greasing points. In this case, the greasing control part **30***c* may increase or decrease the amount of distribution while maintaining the distribution ratio.

(78) Furthermore, the greasing control part **30***c* may determine the changed distribution ratio according to the total operation time of each particular part, the total amount of movement of each work element, the total amount of extension and retraction of each hydraulic cylinder, the cumulative value of the pin surface pressure or PV value of each pin, the work environment of each particular part, the temperature of each pin, how each work element is handled, or the like.

(79) The greasing control part **30***c* may also determine the changed distribution ratio based on the current work mode of the shovel. According to this embodiment, the work mode includes a normal mode (excavation mode) and a crane mode, and is switched using a switch installed in the cabin **10**.

The work mode may also include at least one of a lifting magnet mode and a harvester mode (forestry mode).
(80) Next, a change in the ratio in which grease is distributed among greasing points is described with reference to FIG. **6**. In FIG. **6**, (A) illustrates a temporal transition of greasing state and non-greasing state. On the vertical axis, “ON” represents greasing state and “OFF” represents non-greasing state. The horizontal axis represents the passage of time. In FIG. **6**, (B) illustrates a temporal transition of high-load state (where a work load is high) and non-high-load state (where a work load is not high) with respect to each of the boom-related part, the arm-related part, and the bucket-related part. On the vertical axis, “ON” represents high-load state and “OFF” represents “non-high-load state.” The horizontal axis represents the passage of time and corresponds to the horizontal axis of (A) of FIG. **6**.
(81) In FIG. **6**, (A) illustrates that the non-greasing state that continues for a first set time T**1** and the greasing state that continues for a second set time T**2** are alternately repeated. Furthermore, (A) of FIG. **6** also illustrates that the second set time T**2** includes a period R**1** during which greasing is performed via the first distributor **54-1**, a period R**2** during which greasing is performed via the second distributor **54-2**, and a period R**3** during which greasing is performed via the third distributor **54-3**. Based on these, (A) of FIG. **6** illustrates that the ratio in which grease is distributed among greasing points changes when it is determined that the work load of a particular part is high.
(82) Specifically, when the non-greasing time reaches the first set time T**1** at time t**1**, the greasing control part **30***c* starts greasing over the second set time T**2**. At this point, the greasing control part **30***c* executes the distribution ratio changing process.
(83) According to this embodiment, the greasing control part **30***c* refers to the value of a high load flag stored in the internal memory. In response to determining that none of the boom-related part, the arm-related part, and the bucket-related part is in high-load state during the latest non-greasing state over the first set time T**1**, the greasing control part **30***c* sets the ratio in which grease is distributed among greasing points to initial state (the distribution ratio 50:20:30).
(84) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during the period R**1** corresponding to 50% of the second set time T**2**, performs greasing via the second distributor **54-2** during the period R**2** corresponding to 20% of the second set time T**2**, and performs greasing via the third distributor **54-3** during the period R**3** corresponding to 30% of the second set time T**2**.
(85) Thereafter, when the greasing time reaches the second set time T**2** at time t**2**, the greasing control part **30***c* stops greasing.
(86) Thereafter, at time t**3**, the controller **30** determines that the work load of the bucket-related part is high. For example, the controller **30** determines that the work load of the bucket-related part is high in response to determining that the total operation time of a bucket operating lever during the non-greasing time that has started at time t**2** is more than or equal to a predetermined value.
(87) Specifically, the controller **30**, for example, sets the value of the bucket high load flag to “1” in response to determining that the work load of the bucket-related part is high. The same is the case with other parts such as the boom-related part and the arm-related part.
(88) Thereafter, when the non-greasing time reaches the first set time T**1** at time t**4**, the greasing control part **30***c* resumes greasing. At this point, the greasing control part **30***c* executes the distribution ratio changing process.
(89) At this point, the greasing control part **30***c* refers to the value of the bucket high load flag, and in response to determining that the bucket-related part is in high-load state during the latest non-greasing state over the first set time T**1**, changes the ratio in which grease is distributed among greasing points to 75:5:20. Furtheurtore, the greasing control part **30***c* resets the value of the bucket high load flag to “0” when starting greasing.
(90) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1**

during a period corresponding to 75% of the second set time T**2**, performs greasing via the second distributor **54-2** during a period corresponding to 5% of the second set time T**2**, and performs greasing via the third distributor **54-3** during a period corresponding to 20% of the second set time T**2**.

(91) Thereafter, when the greasing time reaches the second set time T**2** at time t**5**, the greasing control part **30***c* stops greasing.

(92) Thereafter, at time t**6**, the controller **30** determines that the work load of the arm-related part is high. For example, the controller **30** determines that the work load of the arm-related part is high in response to determining that the total amount of movement of the arm **5** during the non-greasing time that has started at time t**5** is more than or equal to a predetermined value.

(93) Specifically, the controller **30**, for example, sets the value of the arm high load flag to "1" in response to determining that the work load of the arm-related part is high.

(94) Thereafter, when the non-greasing time reaches the first set time T**1** at time t**7**, the greasing control part **30***c* resumes greasing. At this point, the greasing control part **30***c* executes the distribution ratio changing process.

(95) At this point, the greasing control part **30***c* refers to the value of the arm high load flag, and in response to determining that the arm-related part is in high-load state during the latest non-greasing state over the first set time T**1**, the greasing control part **30***c* changes the ratio in which grease is distributed among greasing points to 35:45:20. Furthermore, the greasing control part **30***c* resets the value of the arm high load flag to "0" when starting greasing.

(96) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during a period corresponding to 35% of the second set time T**2**, performs greasing via the second distributor **54-2** during a period corresponding to 45% of the second set time T**2**, and performs greasing via the third distributor **54-3** during a period corresponding to 20% of the second set time T**2**.

(97) Thereafter, when the greasing time reaches the second set time T**2** at time t**8**, the greasing control part **30***c* stops greasing.

(98) Thereafter, when the non-greasing time reaches the first set time T**1** at time t**9**, the greasing control part **30***c* resumes greasing. At this point, the greasing control part **30***c* executes the distribution ratio changing process.

(99) Specifically, the greasing control part **30***c* refers to the value of the high load flag, and in response to determining that none of the boom-related part, the airti-related part, and the bucket-related part is in high-load state during the latest non-greasing state over the first set time T**2**, the greasing control part **30***c* sets the ratio in which grease is distributed among greasing points to initial state (the distribution ratio 50:20:30).

(100) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during a period corresponding to 50% of the second set time T**2**, performs greasing via the second distributor **54-2** during a period corresponding to 20% of the second set time T**2**, and performs greasing via the third distributor **54-3** during a period corresponding to 30% of the second set time T**2**.

(101) Thereafter, when the greasing time reaches the second set time T**2** at time t**10**, the greasing control part **30***c* stops greasing.

(102) Next, another example of the distribution ratio changing process is described with reference to FIG. **7**. FIG. **7** is a flowchart of another example of the distribution ratio changing process. The greasing control part **30***c*, for example, executes this distribution ratio changing process when starting greasing by the automatic greaser **50**.

(103) First, the controller **30** determines whether the operation frequency of a particular part is high (step ST**21**). The operation frequency is an example of operating condition information, and according to this embodiment, is expressed as being high or not high.

(104) According to this embodiment, the greasing control part **30***c* determines whether the

operation frequency of a particular part is high, referring to the value of a high frequency flag stored in the internal memory. The high frequency flag may include multiple high frequency flags corresponding to the individual particular parts, such as a boom high frequency flag, an arm high frequency flag, a bucket high frequency flag, and a swing high frequency flag or may be a single high frequency flag representing whether the operation frequency of any of the particular parts is high.

(105) The controller **30**, for example, counts the number of times a hydraulic actuator operates based on the output of the operating pressure sensor **29**. Specifically, the controller **30** counts the number of times of operation of each of the swing hydraulic motor **2**A, the boom cylinder **7**, the arm cylinder **8**, and the bucket cylinder **9** individually. The controller **30**, for example, determines that the operation frequency of the boom-related part is high when the number of times of operation of the boom cylinder **7** is more than or equal to a predetermined value. The same is the case with other particular parts. In response to determining that the operation frequency of a particular part is high, the controller **30** sets the value of the high frequency flag to “1.”

(106) In response to determining that the operation frequency of a particular part is high (YES at step ST**21**), the greasing control part **30***c* changes the ratio in which grease is distributed among greasing points (step ST**22**).

(107) For example, the greasing control part **30***c* changes the ratio in which grease is distributed among greasing points if the value of any of the high frequency flags is “1.” The greasing control part **30***c* changes the ratio in which grease is distributed among greasing points by changing grease distribution time for each of the three distributors **54** without changing the first set time that is a target time for continuing non-greasing state and the second set time that is a target time for continuing greasing state.

(108) For example, in response to determining that the operation frequency of the bucket-related part is high, the greasing control part **30***c* changes the initial distribution ratio 50:20:30 to the distribution ratio 75:5:20.

(109) The greasing control part **30***c*, however, may increase or decrease at least one of the first set time and the second set time and then change the ratio in which grease is distributed among greasing points. In this case, the greasing control part **30***c* may increase or decrease the amount of distribution while maintaining the distribution ratio.

(110) Next, a change in the ratio in which grease is distributed among greasing points is described with reference to FIG. **8**. In FIG. **8**, (A) illustrates a temporal transition of greasing state and non-greasing state. On the vertical axis, “ON” represents greasing state and “OFF” represents non-greasing state. The horizontal axis represents the passage of time. In FIG. **8**, (B) illustrates a temporal transition of high-frequency state (where operation frequency is high) and non-high-frequency state (where operation frequency is not high) with respect to each of the boom-related part, the arm-related part, and the bucket-related part. On the vertical axis, “ON” represents high-frequency state and “OFF” represents “non-high-frequency state.” The horizontal axis represents the passage of time and corresponds to the horizontal axis of (A) of FIG. **8**.

(111) In FIG. **8**, (A) illustrates that the non-greasing state that continues for a first set time T**1** and the greasing state that continues for a second set time T**2** are alternately repeated. Furthermore, (A) of FIG. **8** also illustrates that the second set time T**2** includes the period R**1** during which greasing is performed via the first distributor **54-1**, the period R**2** during which greasing is performed via the second distributor **54-2**, and the period R**3** during which greasing is performed via the third distributor **54-3**. Based on these, (A) of FIG. **8** illustrates that the ratio in which grease is distributed among greasing points changes when it is determined that the operation frequency of a particular part is high.

(112) When the non-greasing time reaches the first set time T**1** at time t**1**, the greasing control part **30***c* starts greasing over the second set time T**2**. At this point, the greasing control part **30***c* executes the distribution ratio changing process of FIG. **7**.

(113) According to this embodiment, the greasing control part **30***c* refers to the value of a high load flag stored in the internal memory, and in response to determining that none of the boom-related part, the aim-related part, and the bucket-related part is in high-frequency state during the latest non-greasing state over the first set time T**1**, sets the ratio in which grease is distributed among greasing points to initial state (the distribution ratio 50:20:30).
(114) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during the period R**1** corresponding to 50% of the second set time T**2**, performs greasing via the second distributor **54-2** during the period R**2** corresponding to 20% of the second set time T**2**, and performs greasing via the third distributor **54-3** during the period R**3** corresponding to 30% of the second set time T**2**.
(115) Thereafter, when the greasing time reaches the second set time T**2** at time t**2**, the greasing control part **30***c* stops greasing.
(116) Thereafter, at time t**3**, the controller **30** determines that the operation frequency of the bucket-related part is high. For example, the controller **30** determines that the operation frequency of the bucket-related part is high in response to determining that the number of times of operation of the bucket cylinder **9** during the non-greasing time that has started at time t**2** is more than or equal to a predetermined value.
(117) Specifically, the controller **30**, for example, sets the value of the bucket high frequency flag to “1” in response to detenuining that the operation frequency of the bucket-related part is high. The same is the case with other parts such as the boom-related part and the aim-related part.
(118) Thereafter, when the non-greasing time reaches the first set time T**1** at time t**4**, the greasing control part **30***c* resumes greasing. At this point, the greasing control part **30***c* executes the distribution ratio changing process of FIG. **7**.
(119) Specifically, the greasing control part **30***c* refers to the value of the bucket high frequency flag, and in response to determining that the bucket-related part is in high-frequency state during the latest non-greasing state over the first set time T**1**, extends the second set time T**2** to a second set time T**2**A and changes the ratio in which grease is distributed among greasing points to 75:5:20. Furthermore, the greasing control part **30***c* resets the value of the bucket high frequency flag to “0” when starting greasing.
(120) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during a period corresponding to 75% of the second set time T**2**A, performs greasing via the second distributor **54-2** during a period corresponding to 5% of the second set time T**2**A, and performs greasing via the third distributor **54-3** during a period corresponding to 20% of the second set time T**2**A.
(121) Thereafter, when the greasing time reaches the second set time T**2**A at time t**5**, the greasing control part **30***c* stops greasing.
(122) Thereafter, at time t**6**, the controller **30** determines that the operation frequency of the boom-related part is high. For example, the controller **30** determines that the operation frequency of the boom-related part is high in response to determining that the number of times of operation of the boom cylinder **7** during the non-greasing time that has started at time t**5** is more than or equal to a predetermined value.
(123) Specifically, the controller **30**, for example, sets the value of the boom high frequency flag to “1” in response to determining that the operation frequency of the boom-related part is high.
(124) Thereafter, when the non-greasing time reaches the first set time T**1** at time t**7**, the greasing control part **30***c* resumes greasing. At this point, the greasing control part **30***c* executes the distribution ratio changing process of FIG. **7**.
(125) Specifically, the greasing control part **30***c* refers to the value of the boom high frequency flag, and in response to determining that the boom-related part is in high-frequency state during the latest non-greasing state over the first set time T**1**, the greasing control part **30***c* shortens the second set time T**2** to a second set time T**2**B (<T**2**) and changes the ratio in which grease is distributed

among greasing points to 25:25:50. Furthermore, the greasing control part **30***c* resets the value of the boom high frequency flag to "0" when starting greasing.
(126) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during a period corresponding to 25% of the second set time T**2**B, performs greasing via the second distributor **54-2** during a period corresponding to 25% of the second set time T**2**B, and performs greasing via the third distributor **54-3** during a period corresponding to 50% of the second set time T**2**B.
(127) Thereafter, when the greasing time reaches the second set time T**2**B at time t**8**, the greasing control part **30***c* stops greasing.
(128) Thereafter, when the non-greasing time reaches the first set time T**1** at time t**9**, the greasing control part **30***c* resumes greasing. At this point, the greasing control part **30***c* executes the distribution ratio changing process of FIG. **7**.
(129) Specifically, the greasing control part **30***c* refers to the value of the high frequency flag, and in response to determining that none of the boom-related part, the arm-related part, and the bucket-related part is in high-frequency state during the latest non-greasing state over the first set time T**1**, the greasing control part **30***c* changes the second set time T**2**B back to the initially set second set time T**2** and sets the ratio in which grease is distributed among greasing points to initial state (the distribution ratio 50:20:30).
(130) In this case, the greasing control part **30***c* performs greasing via the first distributor **54-1** during a period corresponding to 50% of the second set time T**2**, performs greasing via the second distributor **54-2** during a period corresponding to 20% of the second set time T**2**, and performs greasing via the third distributor **54-3** during a period corresponding to 30% of the second set time T**2**.
(131) Thereafter, when the greasing time reaches the second set time T**2** at time t**10**, the greasing control part **30***c* stops greasing.
(132) Thus, the automatic greaser **50** is configured to be able to individually change the amount of grease fed to one greasing point and the amount of grease fed to another greasing point based on information on multiple greasing points. Therefore, a shovel according to an embodiment of the present invention can more appropriately feed grease to each of multiple greasing points.
(133) Next, another example configuration of the distributor **54** is described with reference to FIG. **9**. The distributor **54** of FIG. **9** is different in including four distributors from, but otherwise equal to, the distributor **54** of FIG. **3**, which includes three distributors. Therefore, a description of a common portion is omitted, and differences are described in detail.
(134) According to the example of FIG. **9**, the first distributor **54-1** includes one inlet port and three outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to the first outlet port of the solenoid valve **53**. The hoses extending from the three outlet ports are connected to discharge ports placed at greasing points that are under the harshest lubrication condition in excavation work. The first distributor **54-1** is configured to discharge the same amount of grease as received at the inlet port from each of the three outlet ports in sequential order.
(135) The second distributor **54-2** has one inlet port and six outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to the second outlet port of the solenoid valve **53**. The hoses extending from the six outlet ports are connected to discharge ports placed at greasing points that are under the second harshest lubrication condition in excavation work. The second distributor **54-2** is configured to discharge the same amount of grease as received at the inlet port from each of the six outlet ports in sequential order.
(136) The third distributor **54-3** has one inlet port and five outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to the third outlet port of the solenoid valve **53**. The hoses extending from the five outlet ports are connected to discharge ports placed at greasing points that are under the third harshest lubrication

condition in excavation work. The third distributor **54-3** is configured to discharge the same amount of grease as received at the inlet port from each of the five outlet ports in sequential order.
(137) A fourth distributor **54-4** has one inlet port and five outlet ports. A check valve is attached to a hose extending from each outlet port. A hose extending from the inlet port is connected to a fourth outlet port of the solenoid valve **53**. The hoses extending from the five outlet ports are connected to discharge ports placed at greasing points that are under the fourth harshest lubrication condition in excavation work. The fourth distributor **54-4** is configured to discharge the same amount of grease as received at the inlet port from each of the five outlet ports in sequential order.
(138) According to this configuration, the distributor **54** of FIG. **9** can feed grease to up to 19 greasing points. In FIG. **9**, #**1**, #**2** . . . #**19** denote 19 greasing points. At least two of the **19** greasing points may be the same greasing point.
(139) Table 2 illustrates another example of the correspondence relationship between greasing numbers and greasing points. According to this embodiment, as described above, greasing numbers #**1** through #**4** associated with the first distributor **54-1** are correlated with the discharge ports placed at the greasing points under the harshest lubrication condition in excavation work, and greasing numbers #**5** through #**9** associated with the second distributor **54-2** are correlated with the discharge ports placed at the greasing points under the second harshest lubrication condition in excavation work. Furthermore, greasing numbers #**10** through **414** associated with the third distributor **54-3** are correlated with the discharge ports placed at the greasing points under the third harshest lubrication condition in excavation work, and greasing numbers #**15** through **419** associated with the fourth distributor **54-4** are correlated with the discharge ports placed at the greasing points under the fourth harshest lubrication condition in excavation work.
(140) TABLE-US-00002 TABLE 2 Greasing Number Greasing Point #1 ARM-SIDE LINK PIN GP11 OF FIRST BUCKET LINK 6A #2 ARM TOP PIN GP4 #3 ARM FOOT PIN GP3 #4 ROD-SIDE LINK PIN GPS OF ARM CYLINDER 8 #5 RIGHT SIDE GP10-LK OF ROD-SIDE LINK PIN GP10 OF SECOND BUCKET LINK 6B #6 LEFT SIDE GP10-LK OF ROD-SIDE LINK PIN GP10 OF SECOND BUCKET LINK 6B #7 BUCKET-SIDE LINK PIN GP12 OF SECOND BUCKET LINK 6B #8 RIGHT SIDE OF BOOM FOOT PIN GP2 #9 LEFT SIDE OF BOOM FOOT PIN GP2 #10 CENTER GP10-CY OF ROD-SIDE LINK PIN GP10 OF BUCKET CYLINDER 9 #11 RIGHT SIDE OF BOTTOM-SIDE LINK PIN GP5 OF BOOM CYLINDER 7 #12 LEET SIDE OF BOTTOM-SIDE LINK PIN GP5 OF BOOM CYLINDER 7 #13 RIGHT SIDE OF ROD-SIDE LINK PIN GP6 OF BOOM CYLINDER 7 #14 LEFT SIDE OF ROD-SIDE LINK PIN GP6 OF BOOM CYLINDER 7 #15 BOTTOM-SIDE LINK PIN GP9 OF BUCKET CYLINDER 9 #16 BOTTOM-SIDE LINK PIN GP7 OF ARM CYLINDER 8 #17 FRONT SIDE OF RING GP1 OF SWING MECHANISM 2 #18 REAR SIDE OF RING GP1 OF SWING MECHANISM 2 #19 PINION GEAR OF SWING HYDRAULIC MOTOR 2A
(141) As described above, a shovel according to an embodiment of the present invention includes the undercarriage **1**, the upper swing structure **3** swingably attached to the undercarriage **1**, and the automatic greaser **50** mounted on the upper swing structure **3**. The automatic greaser **50** is configured to be able to individually change the amount of grease fed to one greasing point and the amount of grease fed to another greasing point based on information on the greasing points GP**1** through GP**12**
(142) According to this configuration, the shovel according to an embodiment of the present invention can more appropriately feed a lubricant to multiple greasing points. Therefore, it is possible to prevent a work element from moving with too much lubricant, with insufficient lubricant, with degraded lubricant, or with lubricant in which a foreign object is mixed at a high rate. As a result, it is possible to prevent the occurrence of lubricant leakage (sprinkling), poor lubrication, etc.
(143) Furthermore, the shovel according to an embodiment of the present invention desirably includes the controller **30** serving as a control device to control the automatic greaser **50**. The

automatic greaser **50** desirably includes the grease pump **51** serving as a lubricant pump, the distributor **54** that distributes grease discharged by the grease pump **51**, and the solenoid valve **53** serving as a selector valve placed between the grease pump **51** and the distributors **54**. The controller **30** is desirably configured to be able to individually change the amount of grease fed to one greasing point and the amount of grease fed to another greasing point by controlling the solenoid valve **53** based on the infoLmation on the greasing points GP**1** through GP**12**.
(144) The infoLmation on the greasing points GP**1** through GP**12** may be, for example, infoLmation on the operating condition of the greasing points GP**1** through GP**12** or information on the work environment of the greasing points GP**1** through GP**12**.
(145) The information on the operating condition of the greasing points GP**1** through GP**12** is, for example, at least one of the total operation time of each particular part, the total amount of movement of each work element, the total amount of extension and retraction of each hydraulic cylinder, the cumulative value of the pin surface pressure or PV value of each pin, the temperature of each pin, how each work element is handled, etc. These information items are, for example, obtained using the information obtaining device **73** including the operating pressure sensor **29**, angle sensors, and cylinder pressure sensors.
(146) The information on the work environment of the greasing points GP**1** through GP**12** includes, for example, information on the work environment of each particular part. Specifically, the information on the work environment of the greasing points GP**1** through GP**12** includes at least one of whether a particular greasing point is under water, whether the ambient temperature of a particular greasing point is high, etc. These information items are, for example, obtained using the information obtaining device **73** including an image sensor and a distance sensor.
(147) The greasing points GP**1** through GP**12** may be grouped by work element as illustrated in Table 1, for example, or may be grouped based on the harshness of a lubrication condition as illustrated in Table 2, for example. The automatic greaser **50** is desirably configured to be able to individually change the amount of grease fed to one group and the amount of grease fed to another group.
(148) According to this configuration, the shovel according to an embodiment of the present invention can obtain the information on the greasing points GP**1** through GP**12** at an appropriate time. For example, as illustrated in Table 1, it is possible to individually adjust the amount of grease fed to the greasing points associated with the bucket **6**, the amount of grease fed to the greasing points associated with the arm **5**, and the amount of grease fed to the greasing points associated with the swing mechanism **2** and the boom **4**. Also, as illustrated in Table 2, it is possible to individually adjust the amount of grease fed to greasing points under a harsh lubrication condition and the amount of grease fed to greasing points under a less harsh lubrication condition.
(149) A preferred embodiment of the present invention is described in detail above. The present invention, however, is not limited to the above-described embodiment. Various variations, substitutions, etc., may be applied to the above-described embodiment without departing from the scope of the present invention. Furthermore, the features described with reference to the above-described embodiment may be suitably combined as long as no technical contradiction is caused.
(150) For example, the greasing control part **30***c* may be configured as a device separate from and independent of the controller **30**.
(151) Furthermore, according to the above-described embodiment, the solenoid valve **53** is connected to discharge ports placed at multiple greasing points via the distributors **54**. The solenoid valve **53**, however, may alternatively be directly connected to discharge ports placed at multiple greasing points without the intervention of the distributor **54**. For example, the solenoid valve **53** may be directly connected to each of the **19** greasing points.
(152) Furthermore, inforivation obtained by the shovel **100** may be shared with a manager, operators of other shovels, etc., through a shovel management system SYS as illustrated in FIG. **10**. FIG. **10** is a schematic diagram illustrating an example configuration of the shovel management

system SYS. The management system SYS is a system that manages a shovel **100**. According to this embodiment, the management system SYS is constituted mainly of the shovel **100**, an assist device **200**, and a management apparatus **300**. The shovel **100**, the assist device **200**, and the management apparatus **300** each include a communications device, and are directly or indirectly interconnected via a cellular phone network, a satellite communications network, a short-range radio communications network or the like. Each of the shovel **100**, the assist device **200**, and the management apparatus **300** constituting the management system SYS may be one or more in number. According to the example of FIG. **10**, the management system SYS includes the single shovel **100**, the single assist device **200**, and the single management apparatus **300**.

(153) The assist device **200** is typically a portable terminal device, and is, for example, a computer such as a notebook PC, a tablet PC, or a smartphone carried by a worker or the like at a construction site. The assist device **200** may also be a computer carried by an operator of the shovel **100**. The assist device **200**, however, may also be a stationary terminal device.

(154) The management apparatus **300** is typically a stationary terminal device, and is, for example, a server computer installed in a management center or the like outside a construction site. The management apparatus **300** may also be a portable computer (for example, a portable terminal device such as a notebook PC, a tablet PC, or a smartphone).

(155) At least one of the assist device **200** and the management apparatus **300** (hereinafter, “assist device **200**, etc.”) may include a monitor and an operating device for remote control. In this case, the operator operates the shovel **100** using the operating device for remote control. The operating device for remote control is connected to the controller **30** through, for example, a communications network such as a cellular phone network, a satellite communications network, or a short-range radio communications network.

(156) According to the shovel management system SYS as described above, the controller **30** of the shovel **100** may transmit information on greasing to the assist device **200**, etc. The information on greasing includes, for example, at least one of information on timing to start greasing by the automatic greaser **50**, information on timing to end the greasing, information on greasing points, information on the amount of greasing, information on settings information, information on operating condition information, information on the time at which it is determined that the work load or operation frequency of a particular par is high (hereinafter “determination time”), information on the position of part of the machine body at the determination time, information of the work details of the shovel **100** at the determination time, information on a work environment at the determination time, information on the movement of the shovel **100** measured at the determination time and during a period before and after it, etc. The information on a work environment includes, for example, at least one of information on ground inclination, information on weather, etc. The information on the movement of the shovel **100** includes, for example, a pilot pressure, the pressure of hydraulic oil in a hydraulic actuator, etc.

(157) The controller **30** may be configured to periodically transmit the information on greasing to the assist device **200**, etc., or may be configured to transmit the information on greasing to the assist device **200**, etc., when a predetermined condition is satisfied. The predetermined condition is, for example, that it is determined that the work load or operation frequency of a particular part is high, or the like.

(158) The controller **30** may transmit images captured by an image capturing device to the assist device **200**, etc. The image capturing device is configured to capture an image of a space surrounding the shovel **100**, and may be attached to the shovel **100** or may be attached outside the shovel **100**. The images may be, for example, multiple images that are captured during a predetermined period including the determination time. The predetermined period may include a period preceding the determination time.

(159) Furthermore, the controller **30** may transmit at least one of information on the work details of the shovel **100**, information on the pose of the shovel **100**, information on the pose of the

excavation attachment, etc., during a predetermined period including the determination time to the assist device **200**, etc. This is for enabling a manager using the assist device **200**, etc., to obtain information on a work site. For example, this is for enabling the manager to analyze the cause of the occurrence of a situation where the ratio in which grease is distributed among greasing points has to be changed, and further for enabling the manager to improve the work environment of the shovel **100** based on the results of the analysis.

Claims

1. A shovel comprising: an undercarriage; an upper swing structure swingably attached to the undercarriage; an automatic greater mounted on the upper swing structure, the automatic greater including a lubricant pump; a plurality of distributors configured to distribute a lubricant discharged by the lubricant pump to a plurality of greasing points, the lubricant being a grease; and a selector valve placed between the lubricant pump and the plurality of distributors, the selector valve being configured to selectively connect one of the plurality of distributors to the lubricant pump; and a hardware processor configured to control the automatic greaser, wherein the hardware processor alternately achieves a non-greasing state that continues for a first set time and a greasing state that continues for a second set time whose length is fixed, the hardware processor determines a distribution ratio according to which the second set time is divided into a plurality of greasing times for feeding the grease to the plurality of distributors in the greasing state, based on a work load on each of the plurality of greasing points or an operation frequency of each of the plurality of greasing points, and selectively feeds the grease to the plurality of distributors according to respective greasing times allotted to the plurality of distributors within the second set time in the greasing state, the greasing times being allotted to the plurality of distributors according to the determined distribution ratio, and the hardware processor distributes the grease to the plurality of greasing points according to the greasing times allotted to the plurality of distributors according to the distribution ratio that is initially set in the greasing state, in response to determining that a value representing the work load or the operation frequency is less than a predetermined value in the non-greasing state immediately before the greasing state, and changes the distribution ratio and distributes the grease to the plurality of greasing points according to the greasing times allotted to the plurality of distributors according to the changed distribution ratio without changing the length of the second set time to increase an amount of grease fed to a greasing point among the plurality of greasing points in the greasing state, in response to determining that the value representing the work load on or the operation frequency of the greasing point is more than or equal to the predetermined value in the non-greasing state immediately before the greasing state.
2. The shovel as claimed in claim 1, wherein the hardware processor determines the work load on each of the plurality of greasing points based on information on a work environment of the plurality of greasing points.
3. The shovel as claimed in claim 1, wherein the plurality of greasing points are divided into a plurality of groups by work element, and the hardware processor individually changes an amount of grease fed to a first group among the plurality of groups and an amount of grease fed to a second group among the plurality of groups by controlling the selector valve.
4. The shovel as claimed in claim 1, wherein the plurality of greasing points are divided into a plurality of groups based on harshness of a lubrication condition, and the hardware processor individually changes an amount of grease fed to a first group among the plurality of groups and an amount of grease fed to a second group among the plurality of groups by controlling the selector valve.
5. The shovel as claimed in claim 1, wherein the selector valve is a single solenoid valve having one inlet port connected to a discharge port of the lubricant pump and having a plurality of outlet ports each connected to a different one of the plurality of distributors.

6. The shovel as claimed in claim 1, wherein each of the plurality of distributors has one inlet port connected to the selector valve and has at least one outlet port connected to a discharge port placed at one of the plurality of greasing points.
7. The shovel as claimed in claim 1, wherein the automatic greater performs no greasing during the non-greasing state, and performs greasing during the greasing-state.
8. The shovel as claimed in claim 1, wherein the hardware processor alternately repeats the non-greasing state and the greasing state.