Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 2967921 A1 2018/11/23

(21) 2 967 921

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2017/05/23

(41) Mise à la disp. pub./Open to Public Insp.: 2018/11/23

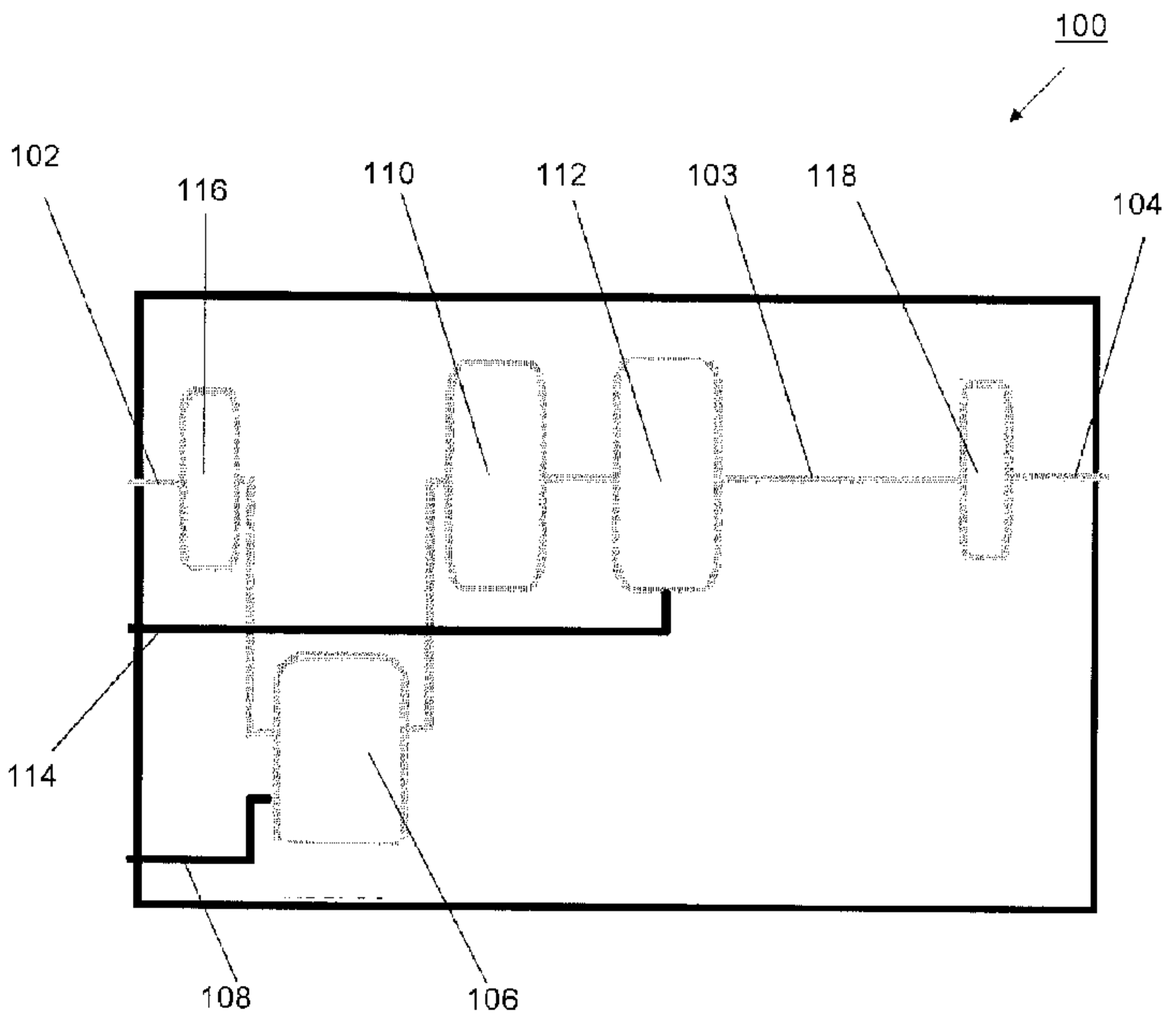
(51) Cl.Int./Int.Cl. *E21B 41/00* (2006.01), *E21B 21/00* (2006.01), *E21B 43/26* (2006.01)

(71) Demandeur/Applicant:
ROUSE INDUSTRIES INC., CA

(72) Inventeurs/Inventors:
ROUSE, CODIE, CA;
ROUSE, JOHN, CA

(74) Agent: FURMAN IP LAW & STRATEGY PC

(54) Titre : GESTION D~ALIMENTATION ELECTRIQUE D~UN APPAREIL DE FORAGE
(54) Title: DRILLING RIG POWER SUPPLY MANAGEMENT



a

(57) Abrégé/Abstract:
A power system and method for the adaptive power control of the drilling rig which includes at least one power consuming component, drilling rig power bus, as well as a mechanical power transmission system. While operating the internal combustion engine in its efficient operating range, unrequired mechanical power is converted to electrical power for storage, or use via the electrical bus on the rig. When the internal combustion engine is not required to provide mechanical or electrical power it is deactivated, and then reactivated - electrical storage on the system in the meantime providing electrical power to the bus as required. The power supply and management system could be retroactively fitted to an existing drilling rig by the incorporation of a generator and electrical storage device thereon. The system and method of the present invention allows for optimized use of combustion based power on a drilling rig, while minimizing environmental emissions from idle running of the at least one internal combustion engine.

ABSTRACT

A power system and method for the adaptive power control of the drilling rig which includes at least one power consuming component, drilling rig power bus, as well as a mechanical power transmission system. While operating the internal combustion engine in its efficient operating range, unrequired mechanical power is converted to electrical power for storage, or use via the electrical bus on the rig. When the internal combustion engine is not required to provide mechanical or electrical power it is deactivated, and then reactivated – electrical storage on the system in the meantime providing electrical power to the bus as required. The power supply and management system could be retroactively fitted to an existing drilling rig by the incorporation of a generator and electrical storage device thereon. The system and method of the present invention allows for optimized use of combustion based power on a drilling rig, while minimizing environmental emissions from idle running of the at least one internal combustion engine.

DRILLING RIG POWER SUPPLY MANAGEMENT

FIELD OF THE INVENTION

The present invention relates to power supply systems for drilling rigs, and more particularly to a drilling rig mud pump drive and a power management system and method associated therewith.

BACKGROUND OF THE INVENTION

System inefficiencies in the power supply of a drilling rig, for example, for use in oil and gas exploration, result in increased fuel consumption and therefore increased emissions output, either due to power losses in the electrical power distribution of large electrical power over a large distance of the drilling rig or due to use of oversized and underutilized mechanical drive systems – in particular the mud pump drive system - that are designed for peak power requirements but are utilized most of the time substantially below peak power, yet have to be in a state of readiness (running) at all times for well control.

Internal Combustion Engine (ICE) systems in compliance with new environmental regulations require higher levels of maintenance load and heat to ensure proper operation of after-treatment systems employed to reduce emissions. Failure to provide adequate load and or heat will result in a deteriorated after-treatment system no longer capable of meeting the new environmental

regulations, thus requiring, for example, a 'Force Regen' process in which the ICE system raises its speed and creates artificial load in order to create high levels of heat in order to clean the after-treatment system by burning the contamination therein.

While fully electric powered drilling rigs using batteries charged by generator sets and power management systems address some of the problems arising from peak or cyclical loads, they have inherent efficiency losses due to the electrical power distribution such as, for example, losses from the generator creating the power, transmission losses between the generator and the battery or load sensing system and between the battery or load sensing system and the drives, and losses in the electric drives. Consequently, there have been developments where the draw-works (hoisting and rotary functions) are electrically driven, while the mud pump(s) – having the largest power consumption - are mechanically driven to take advantage of the efficiencies of the mechanical power train.

Unfortunately, the ICE system driving the mud pump(s) are still underutilized most of their operating time resulting in the aforementioned problems. It is desirable to provide a drilling rig mud pump drive that enables operation of an ICE driving the mud pump within its efficient operating range.

It is also desirable to provide a power management system and method associated with the mud pump drive that enables operation of an ICE driving the mud pump within its efficient operating range.

It is also desirable to provide a power management system and method associated with the mud pump drive that keeps the mud pump drive in a state of readiness while the ICE driving the mud pump is shut off.

SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a drilling rig mud pump drive that enables operation of an ICE driving the mud pump within its efficient operating range.

Another object of the present invention is to provide a power management system and method associated with the mud pump drive that enables operation of an ICE driving the mud pump within its efficient operating range.

Another object of the present invention is to provide a power management system and method associated with the mud pump drive that keeps the mud pump drive in a state of readiness while the ICE driving the mud pump is shut off.

According to one aspect of the present invention, there is provided a drilling rig mud pump drive. The drilling rig mud pump drive comprises an input power drive shaft adapted for being connected to an internal combustion engine for receiving mechanical input power therefrom. An output power drive shaft is adapted for being connected to the drilling rig mud pump for

providing mechanical output power thereto. A mechanical drive train is interposed between the input power drive shaft and the output power drive shaft and mechanically connected thereto. One or more electric generators/motors is mechanically connected to the mechanical drive train. The electric generators or motors can be located anywhere in the mechanical drive train in relation to other components therein, so long as the necessary rotary power for mechanical power of the generator can be provided – as such the generator could be connected right in proximity to the internal combustion engine, or elsewhere along the drive shaft etc. All such approaches are contemplated within the scope of the present invention, either in newly built or retrofitted drilling rigs .

According to the aspect of the present invention, there is provided a power management system. The power management system comprises a processor and a control communications network connected to the processor. The control communications network comprises a mud pump drive control node connected to an internal combustion engine for driving a mud pump of the drilling rig, an electric mud pump motor or generator interposed between the internal combustion engine and the mud pump, and an electric power storage device. A draw-works control node is connected to the electric power storage device and draw-works of the drilling rig. A generator set control node is connected to the electric power storage device, an electric generator set of the drilling rig, and drilling rig main power. The processor controls operation of the internal combustion engine, the electric generator set and the electric mud pump motor or generator in dependence upon power consumption of the mud pump, the draw-works, and the drilling rig main power such that the internal combustion engine for driving the mud pump is operated

within its efficient operating range.

According to the aspect of the present invention, there is provided a method for managing power supply of a drilling rig. A processor is connected via a control communications network to an internal combustion engine for driving a mud pump of the drilling rig, an electric mud pump motor or generator interposed between the internal combustion engine and the mud pump, an electric power storage device, draw-works of the drilling rig, an electric generator set of the drilling rig, and drilling rig main power. Operation of the internal combustion engine, the electric generator set and the electric mud pump motor or generator is controlled in dependence upon power consumption of the mud pump, the draw-works, and the drilling rig main power such that the internal combustion engine for driving the mud pump is operated within its efficient operating range.

The advantage of the present invention is that it provides a drilling rig mud pump drive that enables operation of an ICE driving the mud pump within its efficient operating range.

A further advantage of the present invention is that it provides a power management system and method associated with the mud pump drive that enables operation of an ICE driving the mud pump within its efficient operating range.

A further advantage of the present invention is to provide a power management system and method associated with the mud pump drive that keeps the mud pump drive in a state of

readiness while the ICE driving the mud pump is shut off.

The adaptive power management method of the present invention could be implemented in a pre-existing drilling rig or drilling rig drive train, simply by installing a single generator into an existing drivetrain of a drilling rig and implementing the remainder of the control system and methodology outlined herein. Provision of a retrofit ability for use of pre-existing drilling rigs and drilling rig drivetrains is explicitly contemplated within the scope of the present invention – any method which would allow for the adaptable control of internal combustion power and related other components and the electrical power bus on a drilling rig, as outlined in further detail elsewhere herein, is contemplated within the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention is described below with reference to the accompanying drawings, in which:

Figure 1a is a simplified block diagram illustrating a drilling rig mud pump drive according to a preferred embodiment of the invention;

Figures 1b and 1c are simplified block diagrams illustrating in a front view and a cross-sectional view, respectively, an electric generator with modulating electric motor or

generators of the drilling rig mud pump drive according to the preferred embodiment of the invention;

Figure 2 is a simplified block diagram illustrating a power management system according to a preferred embodiment of the invention; and,

Figure 3 is a simplified block diagram illustrating three different modes of power provision to the mud pump using the power management system according to the preferred embodiment of the invention;

DESCRIPTION OF THE PREFERRED EMBODIMENT

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention belongs. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods and materials are now described.

Referring to Figures 1a to 1c, a drilling rig mud pump drive 100 according to a preferred embodiment of the invention is provided. Input power drive shaft 102 connected to an ICE such as, for example, a high-powered diesel engine (not shown) for receiving mechanical input power therefrom. Output power drive shaft 104 is connected via, for example, a shave and belt drive to

a drilling rig mud pump for providing mechanical output power thereto. The input power drive shaft 102 and the output power drive shaft 104 are connected via a mechanical drive train 103. Any number of different types of connections or transmission arrangements can be understood by those skilled in the art for the connection of the generator 106 to the drivetrain 103 – this could include a transmission, gearbox, clutch, belt drive or any number of other types of connections or transmission arrangements which will be understood to those skilled in the art and are all contemplated within the scope of the present invention.

The number of modulating electric motor or generators 112 is not limited to 5 as illustrated, but may be varied between 1 and any number with a larger number of modulating electric motor or generators 112 providing more flexibility in operating the drilling rig mud pump drive 100 at the expense of higher complexity and cost. The modulating electric motor or generators 112 are of conventional technology. For example, regular AC asynchronous electric motors can usually be employed as electric generators without any internal modifications. The electric generator 106 and the modulating electric motor or generators 112 are electrically connected to the electrical power system of the drilling rig via electric connections 108 and 114, respectively.

The drilling rig mud pump drive 100 also comprises a mechanism 116 for separating the ICE from the drive train 110. For example, the drilling rig mud pump drive 100 for driving a mud pump using a ICE comprises an electric generator 106 and five modulating electric motor or generators 112 as shown. Preferably, the modulating electric motor or generators 112 are designed to provide sufficient mechanical power for driving the mud pump in order to keep the

drilling rig mud pump drive 100 in a state of readiness while the ICE driving the mud pump is shut off.

Referring to Figure 2, a power management system 200 according to a preferred embodiment of the invention is provided. The mud pump (not shown) is mechanically 220 driven by ICE 10 via sheave 12 connected to the mud pump drive 100. The power management system 200 comprises a processor 202 such as, for example, a conventional off-the-shelf Field-Programmable Gate Array (FPGA), connected to a control communications network 224, 226. For example, the processor 202 and the control communications network 224, 226 are implemented as a conventional Controller Area Network (CAN) bus with the processor 202 forming 'Master Control' communicating with, for example, control nodes 204, 206, 208, and 210.

Mud pump drive control node 204 is connected to: ICE 10 for driving a mud pump of the drilling rig via shave 12; modulating electric motor or generators 112; and electric power storage device 20 of the drilling rig. Generator control node 18 is connected to: the electric generator 106, the electric power storage device 20; drilling rig power bus 18 (the drilling rig power bus 18 being any electric power consumer of the drilling rig other than draw-works 14 and the modulating electric motor or generators 112 connected to the electric supply network of the drilling rig); and the mud pump drive control node 204. Draw-works control node 206 is connected to: the electric power storage device 20; and draw-works 14 of the drilling rig. Generator set control node 208 is connected to: the electric power storage device 20; electric generator set 16 of the drilling rig; and the drilling rig power bus 18.

Electric power transmission lines 222 connect the electric generator 106 and the modulating electric motor or generators 112 via control nodes 204 and 210 to the electric power storage device 20 and the drilling rig power bus 18, as well as the draw-works 14 and the electric generator set 16 via control nodes 206 and 208 to the electric power storage device 20 and the drilling rig power bus 18. The electric power is converted where necessary from AC to DC, for example, for battery or load sensing system storage, using conventional rectifiers and from DC to AC using conventional inverters.

The processor 202 controls operation of the ICE 10, the electric generator set 16, the electric generator 106, and the modulating electric motor or generators 112 in dependence upon the power consumption of the mud pump (sheave 12), the draw-works 14, and the drilling rig power bus 18 such that the ICE 10 is operated within its efficient operating range.

Figure 3 illustrates three modes of operation of the power management system 200. In mode I, the electric generator 106, and the modulating electric motor or generators 112 produce electric power 234 for storage in the electric power storage device 20 when the mechanical power consumption 232 of the mud pump is less than the power 230 produced by the ICE 10 when operated in its efficient range P1. In mode II, the modulating electric motor or generators 112 produce mechanical power 236 when the mechanical power consumption 232 of the mud pump (for example, peak power) is greater than the power 230 produced by the ICE 10 when operated in its efficient range P1. In mode III, the modulating electric motor or generators 112 produce

mechanical power 238 for driving the mud pump while the ICE 10 is shut off. For example, mode III is employed during the state of readiness or when the power consumption of the mud pump is less than the power produced by the ICE 10 and the excess power cannot be used in other parts of the electric supply network of the drilling rig.

The three modes of operation of the power management system 200 provide substantial efficiency increase and emissions reduction by:

Mode I: operating the ICE 10 in its efficient range and providing excess as electric power to the electric supply network of the drilling rig (which also substantially obviates the use of 'Force Regen' processes);

Mode II: enabling employment of a smaller ICE 10 than needed to provide peak power to the mud pump by importing electrical power as required to add power to the drivetrain; and,

Mode III: shutting the ICE 10 off, reducing run-time of the ICE which has the additional advantages of increasing the overall life-time and reducing the maintenance of the ICE 10, also leaving unit in the state of readiness as dictated by the application.

It will be apparent to those of skill in the art that by routine modification the present invention can be optimized for use in a wide range of conditions and application. It will also be obvious to

those of skill in the art that there are various ways and designs with which to produce the apparatus and methods of the present invention. The illustrated embodiments are therefore not intended to limit the scope of the invention, but to provide examples of the apparatus and method to enable those of skill in the art to appreciate the inventive concept.

Those skilled in the art will recognize that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the scope of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

We claim:

1. A power management system for use on a drilling rig comprising at least one power-consuming component, at least one electric power storage device, at least one internal combustion engine and an electric generator set providing power to a drilling rig power bus, said system comprising:

    a. a processor; and

    b. a control communications network connected to the processor, the control communications network comprising:

        i. a generator set control node operatively connected to control the at least one electric power storage device, the electric generator set and the at least one internal combustion engine; and

        ii. at least one component control node operatively connected to control power supply to a power-consuming component of the drilling rig from at least one power generating or storage component of the drilling rig;

wherein the processor controls operation of the internal combustion engine, the electric generator set and the electric power storage device in dependence upon power consumption of the at least one power-consuming component and the drilling rig power bus, such that the internal combustion engine is operated within its efficient operating

range while providing necessary power to the components of the rig requiring same.

2. The power management system of Claim 1 wherein the drilling rig is a pre-existing drilling rig with a conventional power system, and the electric generator set and the electric power storage device are components added to the drilling rig along with the power management system to enable adaptive power management of a pre-existing drilling rig and drive train.

3. The power management system of claim 1 wherein the at least one component control node comprises a mud pump drive control node operatively connected to a mud pump of the drilling rig driven by the internal combustion engine, an electric mud pump motor or generator interposed between the internal combustion engine and the mud pump, and an electric power storage device.

4. The power management system of claim 3 wherein the electric mud pump motor or generator comprises an electric generator and at least one modulating electric motor or generator, wherein the mud pump drive control node is connected to the at least one modulating electric motor or generator and a generator control node connected to the electric generator, the electric power storage device, and the drilling rig power bus.

5. The power management system of claim 1 wherein the at least component control node comprises a draw-works control node connected to the electric power storage device and draw-works of the drilling rig.

6. An adaptively powered drilling rig, comprising:

a. at least one power-consuming component;

b. at least one electric power storage device;

c. at least one internal combustion engine connected to an electric generator set providing power to a drilling rig power bus; and

d. a power management system comprising:

i. a processor; and

ii. a control communications network connected to the processor, the control communications network comprising:

1. a generator set control node operatively connected to control the at

least one electric power storage device, the electric generator set and the at least one internal combustion engine; and

2. at least one component control node operatively connected to control power supply to a power-consuming component of the drilling rig from at least one power generating or storage component of the drilling rig;

wherein during operation of the drilling rig the processor controls operation of the internal combustion engine, the electric generator set and the electric power storage device in dependence upon power consumption of the at least one power-consuming component and the drilling rig power bus, such that the internal combustion engine is operated within its efficient operating range while providing necessary power to the components of the rig requiring same.

7. The adaptively powered drilling rig of Claim 6 further comprising a mud pump driven by the internal combustion engine, wherein the at least one component control node comprises a mud pump drive control node operatively connected to the mud pump, an electric mud pump motor or generator interposed between the internal combustion engine and the mud pump, and an electric power storage device.

8. The adaptively powered drilling rig of Claim 7 wherein the electric mud pump motor or generator comprises an electric generator and at least one modulating electric motor or generator, wherein the mud pump drive control node is connected to the at least one modulating electric motor or generator and a generator control node connected to the electric generator, the electric power storage device, and the drilling rig power bus.

9. The adaptively powered drilling rig of Claim 6 wherein at least one power-consuming component of the drilling rig is draw-works, and wherein the at least component control node comprises a draw-works control node connected to the electric power storage device and the draw-works.

10. A drilling rig mud pump drive comprising:

a. an input power drive shaft adapted for being connected to an internal combustion engine for receiving mechanical input power therefrom;

b. an output power drive shaft adapted for being connected to the drilling rig mud pump for providing mechanical output power thereto;

c. a mechanical drive train interposed between the input power drive shaft and the

output power drive shaft and mechanically connected thereto;

d. an electric generator mechanically connected to the mechanical drive train; and

e. at least one modulating electric motor or generator mechanically connected to the mechanical drive train.

11. The drilling rig mud pump drive of claim 10 wherein the at least one modulating electric motor or generator is capable of providing sufficient mechanical power for driving the mud pump.

12. A method for managing power supply on a drilling rig, said method comprising:

a. providing a processor connected via a control communications network to an internal combustion engine for driving a mud pump of the drilling rig, an electric mud pump motor or generator interposed between the internal combustion engine and the mud pump, an electric power storage device, an electric generator set of the drilling rig, drilling rig power bus and at least one power-consuming component of the drilling rig; and

b. during operation of the drilling rig, controlling operation of the internal combustion engine, the electric generator set and the electric mud pump motor or generator in dependence upon power consumption of the power-consuming components of the drilling rig and the drilling rig power bus such that the internal combustion engine for driving the mud pump is operated within its efficient operating range.

13. The method of claim 12 wherein the electric mud pump motor or generator produces electric power for storage in the electric power storage device when the mechanical power consumption of the mud pump is less than the power produced by the internal combustion engine when operated in its efficient range.

14. The method of claim 12 wherein the electric mud pump motor or generator produces mechanical power when the mechanical power consumption of the mud pump is greater than the power produced by the internal combustion engine when operated in its efficient range.

15. The method of claim 12 wherein the electric mud pump motor or generator produces mechanical power for driving the mud pump and wherein the internal combustion engine

is shut off.

16. The method of claim 15 wherein the internal combustion engine is shut off when the power consumption of the mud pump is less than the power produced by the internal combustion engine when operated in its efficient range.

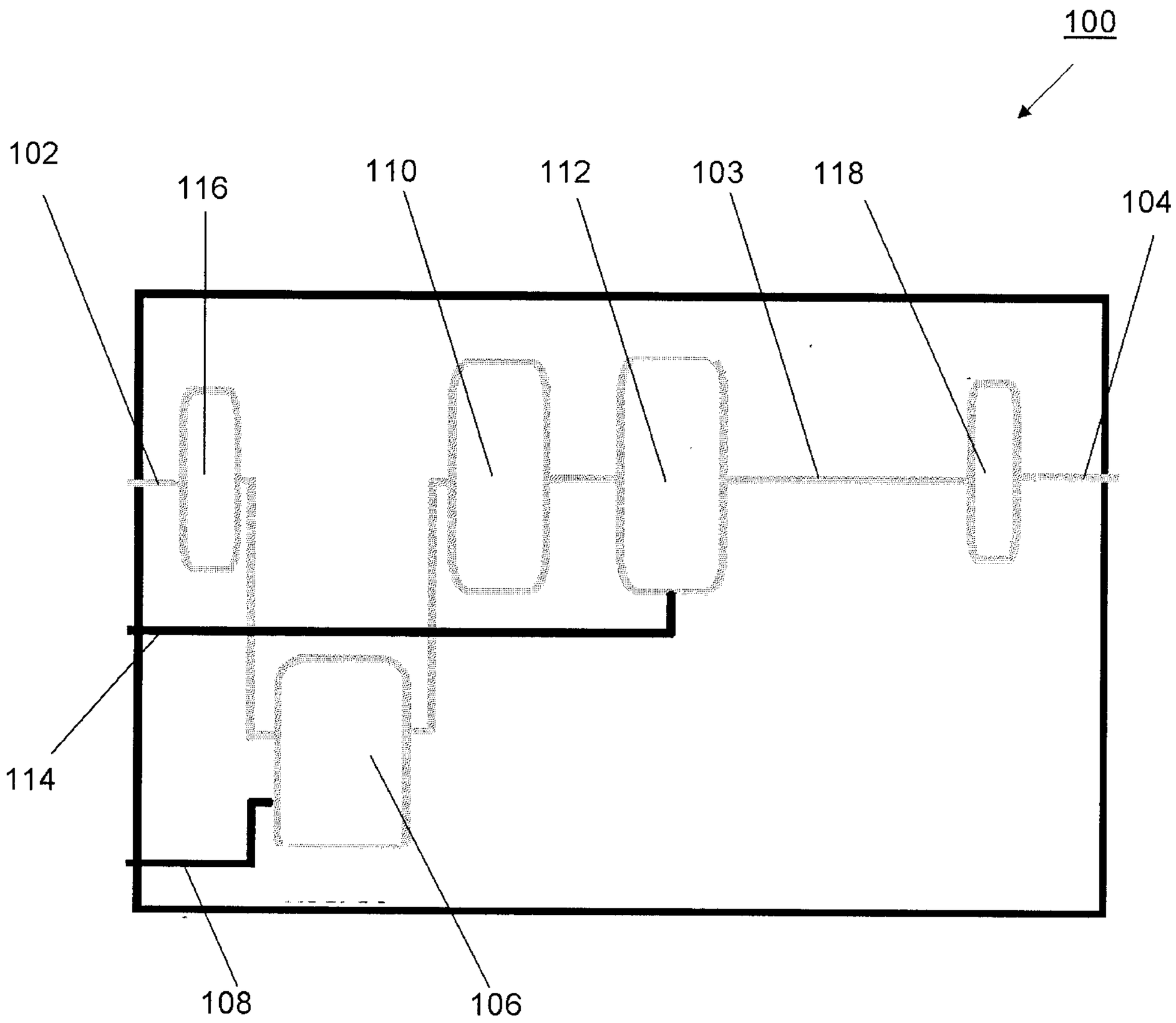


Figure 1a

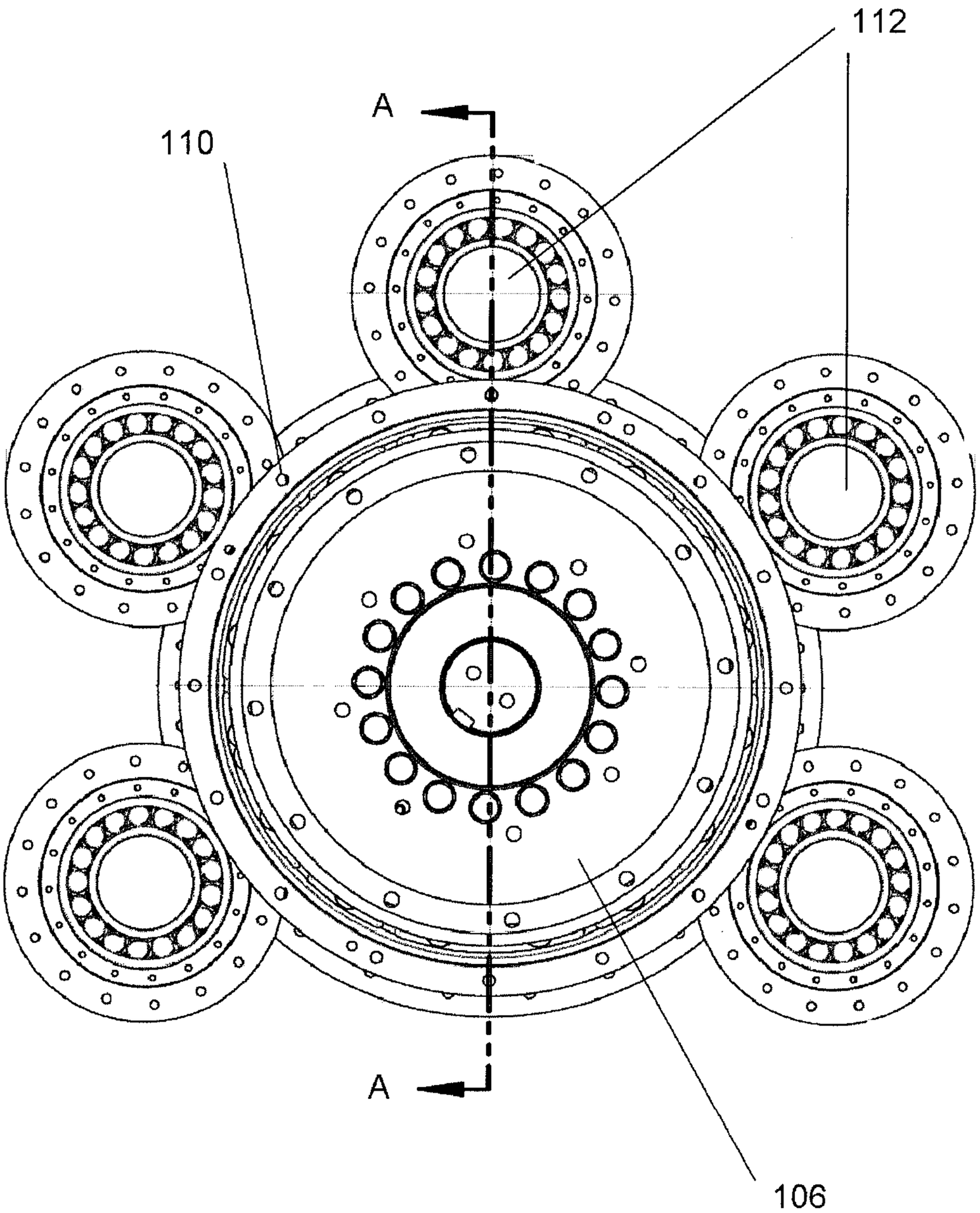


Figure 1b

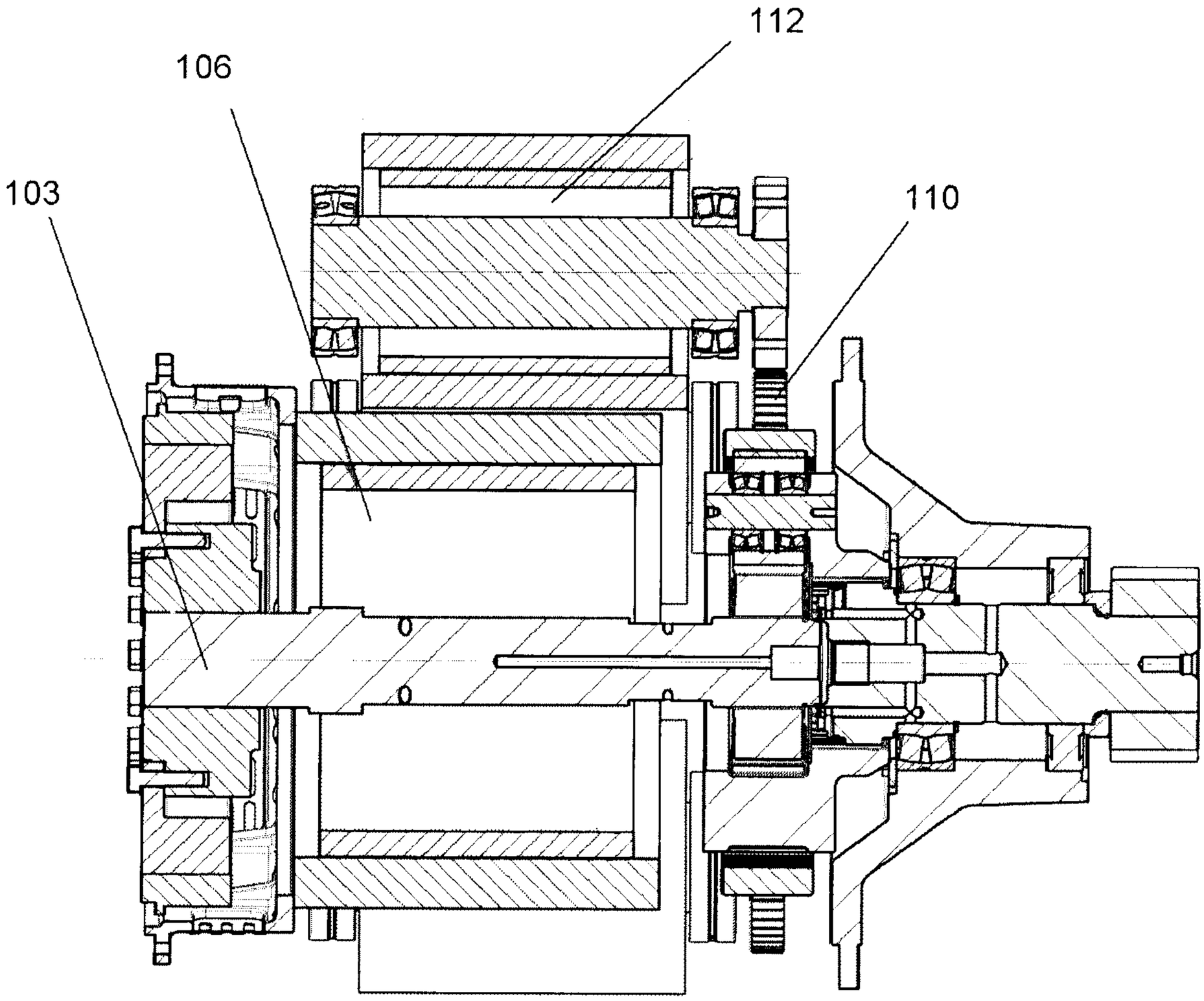


Figure 1c (Section A – A)

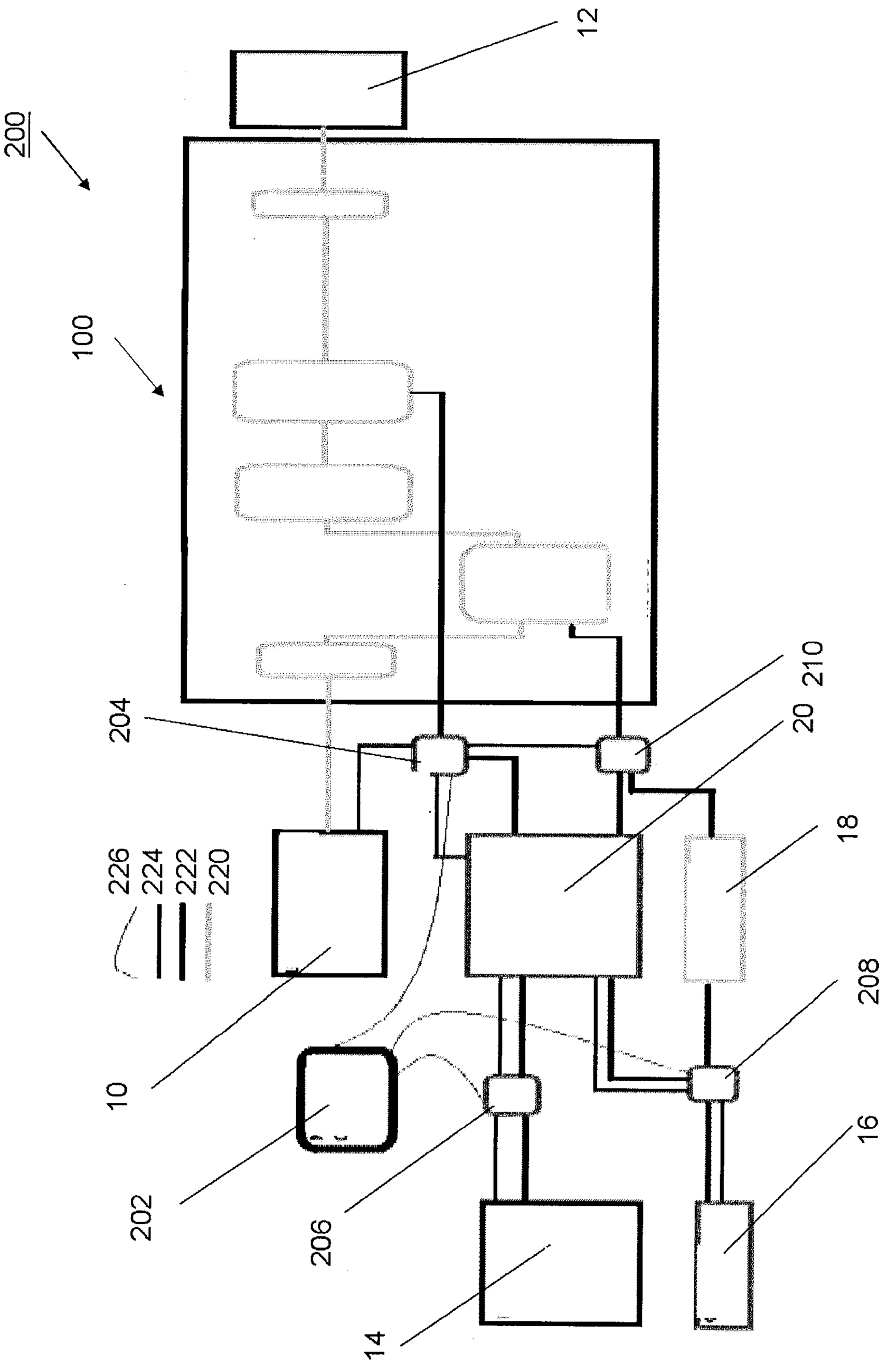


Figure 2

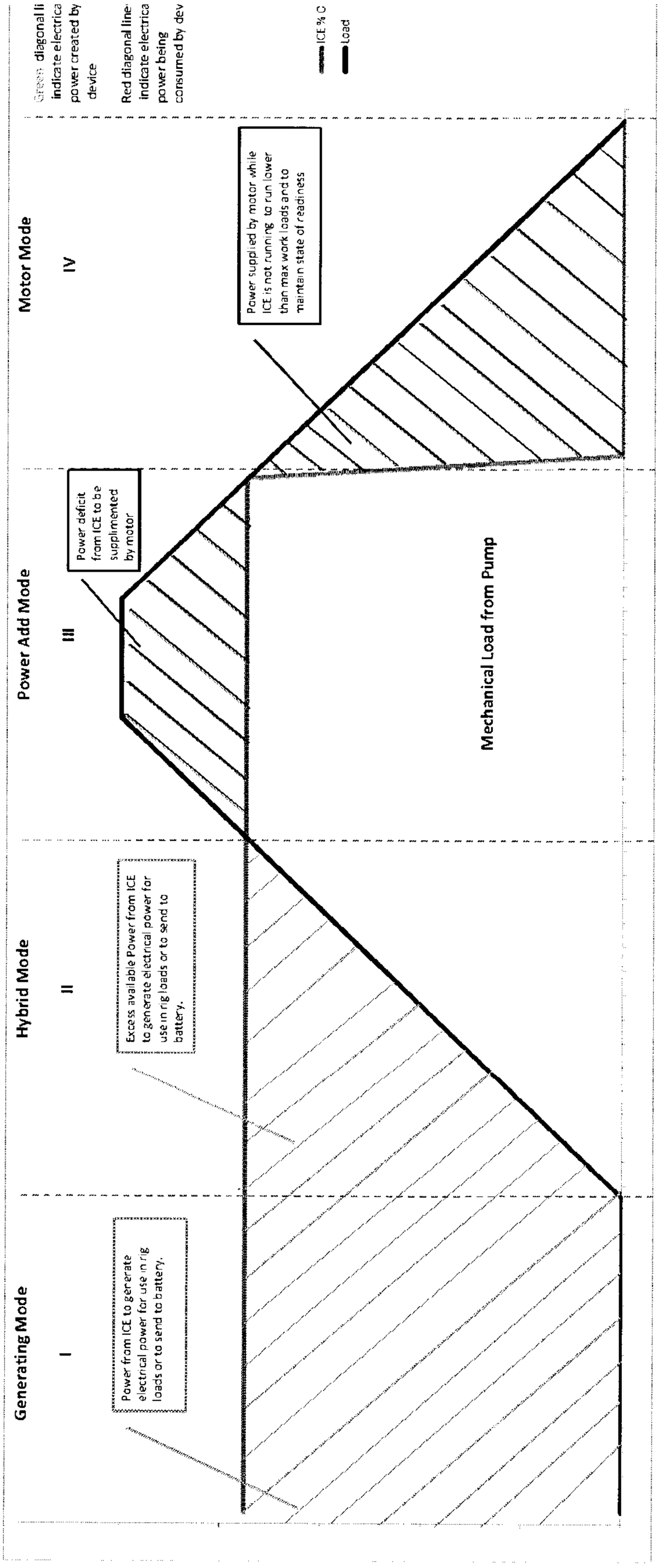
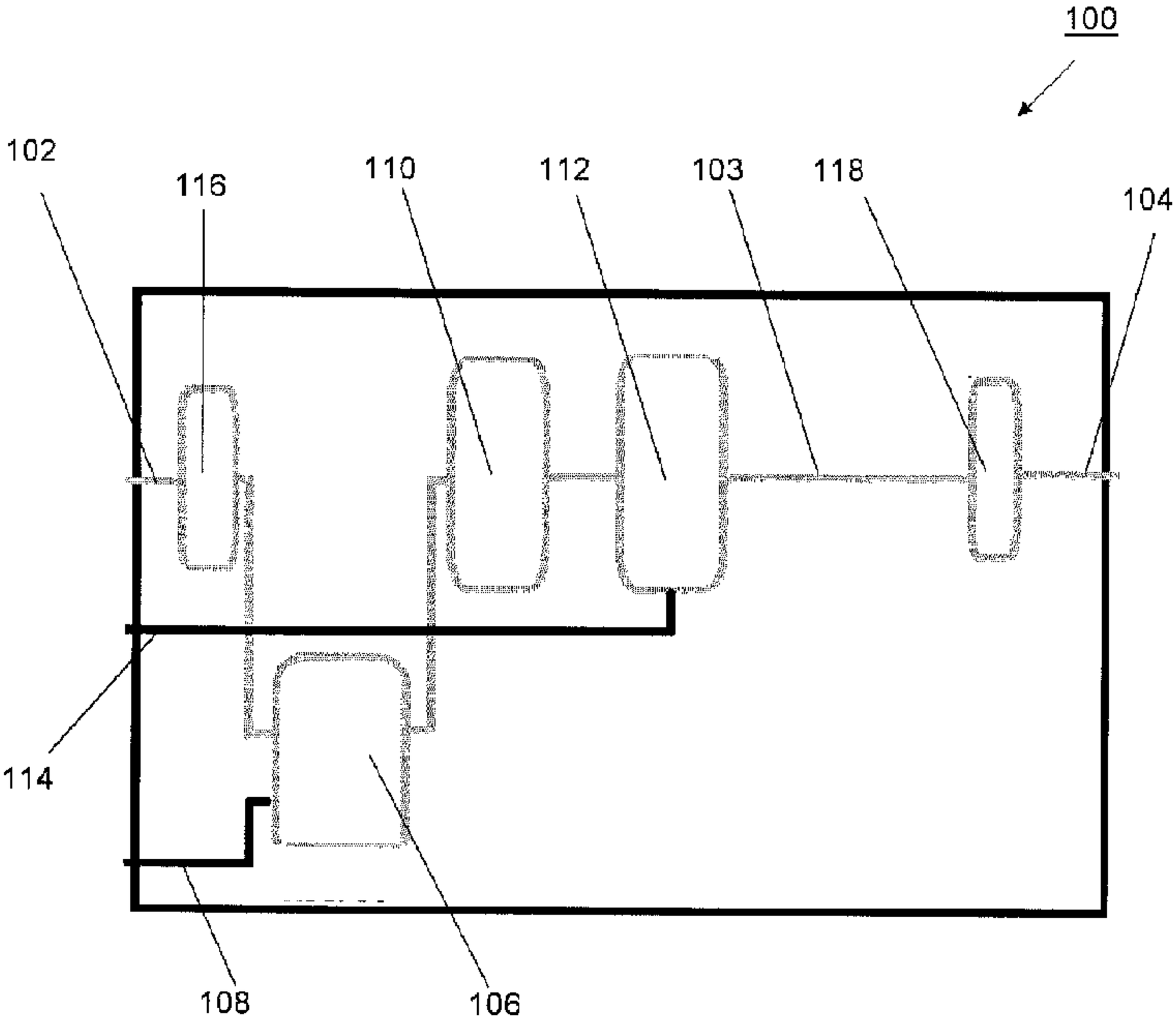

Motor Mode
IV
Green diagonal li
indicate electrica
power created by
device
Red diagonal line
indicate electrica
power being
consumed by dev
Power supplied by motor while ICE is not running to run lower than max work loads and to maintain state of readiness
ICE % C
Load
Power Add Mode
III
Power deficit from ICE to be supplimented by motor
Mechanical Load from Pump
Hybrid Mode
II
Excess available Power from ICE to generate electrical power for use in rig loads or to send to battery.
Generating Mode
I
Power from ICE to generate electrical power for use in rig loads or to send to battery.

FIGURE 3



a