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(54) **MULTISTAGE PNEUMATIC MOTOR**

(57) A multistage pneumatic motor includes a shell (1) and a power output main shaft (2). The shell (1) is provided with a gas inlet (3) and a gas outlet (4). Two or more pneumatic motor stages (11, 12, 13) are installed in the shell (1). The first pneumatic motor stage is communicated with the gas inlet (3), and the last pneumatic motor stage is communicated with the gas outlet (4). Compressed gas enters the shell (1) through the gas inlet (3), drives the first pneumatic motor stage, then drives the next pneumatic motor stage, and is exhausted from the shell (1) through the gas outlet (4) at last. Every pneumatic motor stage is provided with a power output shaft (112, 122, 132) which is connected to the power output main shaft (2), so that the powers produced by all pneumatic motor stages (11, 12, 13) are jointed together and then output by the power output main shaft (2). The multistage pneumatic motor improves working efficiency greatly, saves energy source and reduces noise.

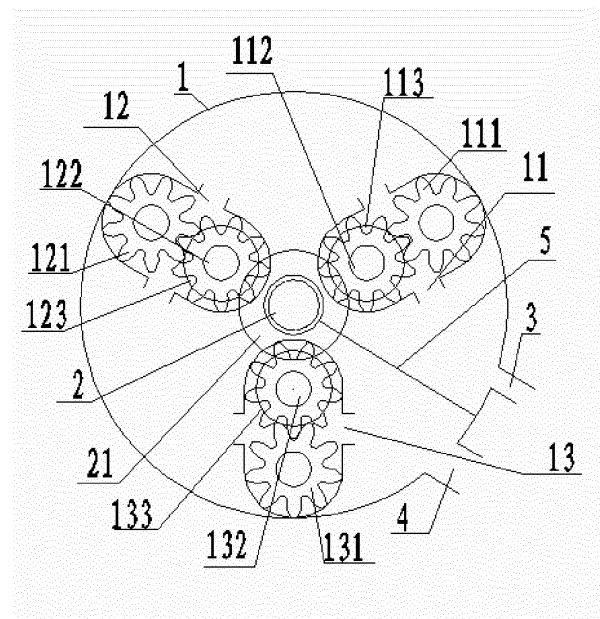


Fig. 3

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a pneumatic motor which belongs to the field of mechanical engineering and is used on sites of industrial and mining operation, and particularly relates to an energy-saving and efficient multistage pneumatic motor.

BACKGROUND OF THE INVENTION

[0002] A pneumatic motor is a mechanical device which takes compressed air as a power source, and has been widely used due to advantages of being light and safe and etc., and is especially widely used on operation sites where electricity is not allowed as a power source and is also a must. Currently used pneumatic motors are all single stage motors. Wherein, the pneumatic motors have many forms of structures, comprising a gear-type motor, a plunger-type motor, a vane-type motor, a screw-type motor and etc., and the most widely used motor in industry such as coal mining is the gear-type motor. The single stage gear-type pneumatic motor is to provide a pair of gears engaging with each other within a shell, in which the gear shaft of one gear is a power output shaft connected with devices such as a reducer and outputs power. The shell of the gear-type pneumatic motor is respectively provided with an inlet and an outlet for the compressed air, and when passing the gear-type pneumatic motor, the compressed air pushes the gears of the motor to rotate, thereby forming power output. However, current single stage pneumatic motors have a low working efficiency, the working efficiencies of usual pneumatic motors are not greater than 30%, and the compressed air passes a pair of motor gears and then is directly discharged to the air via the gas outlet, while the gas discharged through the gas outlet still has much energy, thus this results in large energy consumption and low efficiency, and the energy loss of current pneumatic motors is about 70%, which renders huge energy waste; also, discharging such gas with much energy through the shell of the motor would render much noise and even squeaking, which is a pollution to operating personnel and the environment, and does not comply with current requirements on low carbon, energy saving and environment protection.

SUMMARY OF THE INVENTION

Technical problems

[0003] To solve the above problems of or at least one of the above problems of the single stage pneumatic motors in the prior art such as low efficiency, huge energy consumption and large noise, the present invention puts forward the following technical solutions, so that the pneumatic motors achieve a greatly improved efficiency

and obviously decreased noise.

Technical solutions

[0004] A multistage pneumatic motor provided by the present invention comprises a shell and a power output main shaft, and the shell is provided with a gas inlet and a gas outlet, characterized in that, two or more pneumatic motor stages are installed in the shell, the first pneumatic motor stage among the two or more pneumatic motor stages is communicated with the gas inlet, and the last pneumatic motor stage is communicated with the gas outlet, a power gas enters the shell through the gas inlet, drives the first pneumatic motor stage and then the second pneumatic motor stage, then drives the next pneumatic motor stage, and is exhausted from the shell through the gas outlet at last, every pneumatic motor stage is provided with a power output shaft which is connected to the power output main shaft, so that the powers produced by all the pneumatic motor stages are joined together and then output by the power output main shaft.

[0005] Preferably, the rotating speeds delivered by the power output shafts of each stage of the pneumatic motor to the power output main shaft are the same, so that the powers produced by each stage of the pneumatic motor are joined forwardly and then outputted by the power output main shaft.

[0006] The pneumatic motor is a gear motor, a vane motor, a plunger motor or a screw motor.

[0007] Preferably, when the pneumatic motor is a gear motor, the shell is provided therein with a first pneumatic motor stage consisting of a pair of a first-stage motor gear and a second pneumatic motor stage consisting of a pair of a second-stage motor gear, one gear shaft of the first-stage motor gears is the power output shaft of the first pneumatic motor stage, one gear shaft of the second-stage motor gears is the power output shaft of the second pneumatic motor stage, the power output shaft of the first pneumatic motor stage, the power output shaft of the second pneumatic motor stage and the power output main shaft are the same shaft, the first-stage motor gear and the second-stage motor gear have the same number of teeth and the same modulus, and the first-stage motor gear is shorter than that of the second-stage motor gear, so that the rotating speed of the power output shaft of the first pneumatic motor stage is the same with the rotating speed of the power output shaft of the second pneumatic motor stage.

[0008] Preferably, when the pneumatic motor is a gear motor, the shell is provided therein with a first pneumatic motor stage consisting of a pair of a first-stage motor gear, a second pneumatic motor stage consisting of a pair of a second-stage motor gear and a third pneumatic motor stage consisting of a pair of a third-stage motor gear, and the power output shafts of the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage are connected with the power output main shaft through a transmission gear.

[0009] Furthermore, the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage surround the power output main shaft and are arranged in a circular shape, the power output main shaft is located at the centre of the respective pneumatic motor stages, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, the transmission gear comprises a driving gear provided on the power output shaft of each pneumatic motor stage and a driven gear provided on the power output main shaft while engaging with the driving gear of each pneumatic motor stage.

[0010] Preferably, the driving gear provided on the power output shaft of each pneumatic motor stage is a gear formed on the power output shaft, so that the power output shaft of each pneumatic motor stage becomes a driving gear shaft, and the driving gears on the driving gear shafts of respective pneumatic motor stages have the same the modulus and the same number of teeth.

[0011] Or, the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage are arranged in a linear shape, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, the transmission gear comprises three first-stage driving gears provided on the power output shaft of each pneumatic motor stage, two first-stage driven gears simultaneously engaging with the first-stage driving gears of the adjacent pneumatic motor stages, two second-stage driving gear shafts being respectively coaxial with the two first-stage driven gears, and one second-stage driven gear simultaneously engaging with the two second-stage driving gear shafts, and the one second-stage driven gear shaft is provided on the power output main shaft.

[0012] Furthermore, the three first-stage driving gears have the same modulus and the same number of teeth, the two first-stage driven gears have the same modulus and the same number of teeth, and the two second-stage driving gear shafts have the same modulus and the same number of teeth.

[0013] Preferably, the first-stage motor gear, the second-stage motor gear and the third-stage motor gear have the same number of teeth and the same gear length, and the modulus of the gears increase stage by stage so that the rotating speeds of the power output shafts of the respective pneumatic motor stages are the same.

[0014] Or, the first-stage motor gear, the second-stage motor gear and the third-stage motor gear have the same number of teeth and the same modulus, and the lengths of the gears increase stage by stage so that the rotating speeds of the power output shafts of the respective pneumatic motor stages are the same.

[0015] Or, the first-stage motor gear, the second-stage motor gear and the third-stage motor gear have the same modulus and the same gear length, and the numbers of the teeth of the gears increase stage by stage so that the rotating speeds of the power output shafts of the respective pneumatic motor stages are the same.

[0016] Preferably, the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage surround the power output main shaft and are arranged in a circular shape, the power output main shaft is located at the centre of the respective pneumatic motor stages, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, the transmission gear comprises respective transmission gears of the respective motor gear stages with different reduction ratios and a driven gear provided at the power output main shaft, and the rotating speeds delivered from the respective pneumatic motor stages to the power output main shaft are the same.

15 Advantageous effects

[0017] For the multistage pneumatic motor provided according to the present invention, multiple pneumatic motor stages are provided within the shell, and the powers at the power output shafts of the multiple pneumatic motor stages are joined together and then output through a power output main shaft, that is, multiple pneumatic motors are connected in series and used jointly, then the gas energy of the compressed air is fully used, so that the gas energy discharged out of the pneumatic motor are lowered to the minimum extent, and the energy of the compressed air is fully used, thereby improving the working efficiency of the pneumatic motor and lowering the noise of the discharged gas. From experiments, the efficiency of the three-stage pneumatic gear motor provided by the present invention can be enhanced by 40%-50% compared with the current single-stage pneumatic gear motor, and the noise can be lowered by at least 10 decibels based on the prior art.

[0018] The working principle of the multistage pneumatic motor of the present invention is as follow: after the compressed air enters the shell of the multistage motor, the pressure of the gas lowers while its volume increases after passing each pneumatic motor stage, then, according to a gas state equation, without considering temperature changes, the pressure of the gas is in inverse proportion to the volume of the gas, that is, the volume of the gas will increase when the pressure of the gas lowers. The present invention fully considers the changes of gas pressure and volume between multistage motor, and uses many methods to achieve that the rotating speeds delivered from the respective motor stages to the power output main shaft are substantially the same, so as to reduce the mutual interference between the respective motor stages and achieve the forward joining of the powers of the respective pneumatic motor stages, which greatly enhances the total output power.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a schematic diagram of the structure of a

two-stage pneumatic gear motor of the present invention;

Fig. 2 is a schematic diagram of the structure of a three-stage pneumatic gear motor of the present invention;

Fig. 3 is a top diagram of the Fig. 2;

Fig. 4 is a schematic diagram of the structure of another three-stage pneumatic gear motor of the present invention; and

Fig. 5 is a top diagram of the Fig. 4.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0020] To more clearly understand the above objects, features and advantages of the present invention, the present invention will be further described in details hereinafter in conjunction with the accompanying drawings and specific embodiments.

[0021] Many specific details are explained in the following description for the convenience of fully understanding the present invention, however, the present invention can be implemented with other manners different from those described herein, and therefore, the present invention is not limited by the following specific embodiments to be disclosed.

[0022] Embodiment 1: Fig. 1 illustrates the structure of a two-stage pneumatic gear motor of the present invention, and the two-stage pneumatic motor comprises a shell 1 and a power output main shaft 2, and the shell 1 is provided with a gas inlet 3 and a gas outlet 4, characterized in that, the shell 1 is provided therein with two pneumatic gear motor stages, i.e., a first pneumatic gear motor stage 11 consisting of a pair of a first-stage motor gear 111 and a second pneumatic gear motor stage 12 consisting of a pair of a second-stage motor gear 121, the first pneumatic gear motor stage 11 is communicated with the gas inlet 3, the last pneumatic gear motor stage, i.e., the second pneumatic gear motor stage 12, is communicated with the gas outlet 4, and a power gas enters the shell 1 through the gas inlet 3 and then drives the first pneumatic gear motor stage 11 and then the second pneumatic gear motor stage 12, and is finally discharged out of the shell 1 through the gas outlet 4, the first pneumatic gear motor stage 11 is provided with a power output shaft 112, the second pneumatic gear motor stage is provided with a power output shaft 122, the power output shaft 112 of the first pneumatic gear motor stage 11 and the power output shaft 122 of the second pneumatic gear motor stage 12 are connected with the power output main shaft 2, so that the powers produced by the pneumatic gear motor stages are joined together and then output by the power output main shaft 2. In this way, each pneumatic gear motor stage is provided with a power output

shaft, and the power output shaft of each pneumatic gear motor stage is connected with the power output main shaft, so that the powers produced by each of the pneumatic gear motor stages are joined together and then output by the power output main shaft, thus the energy of the compressed gas is fully used, the efficiency of the pneumatic motor is improved, and the speed and the pressure of the fully used compressed gas discharged out of the shell are lowered greatly, and thus the noise of the pneumatic motor is decreased.

[0023] Preferably, the rotating speeds delivered from the power output shafts of each stage of the pneumatic gear motor to the power output main shaft are the same, so that the powers produced by each stage of the pneumatic gear motor are joined forwardly and then outputted by the power output main shaft. In this way, the power gas can be used to the most extent to improve the efficiency of the pneumatic motor to the greatest extent. In this embodiment, one gear shaft of the first-stage motor gears 111 is the power output shaft 112 of the first pneumatic gear motor stage 11, one gear shaft of the second-stage motor gears 121 is the power output shaft 122 of the second pneumatic gear motor stage 12, the power output shaft 112 of the first pneumatic gear motor stage 11, the power output shaft 122 of the second pneumatic gear motor stage 12 and the power output main shaft 2 are the same shaft, and the first-stage motor gear 111 and the second-stage motor gear 121 have the same number of teeth and the same modulus, and the first-stage motor gear 111 is shorter than the second-stage motor gear 121, so that the rotating speed of the power output shaft 112 of the first pneumatic gear motor stage 11 is the same with the rotating speed of the power output shaft 122 of the second pneumatic gear motor stage 12. As for the relationship between the lengths of the first-stage motor gear 111 and the second-stage motor gear 121, it can be determined according to the inverse proportion relationship between the pressure and the volume of the compressed air and then in combination with the value of the compressed air which has passed the two pneumatic gear motor stages. This can be rendered via simple mathematic calculation, which can be conducted by those skilled in the art and thus is omitted herein.

[0024] Although the above embodiment 1 describes the pneumatic gear motor, those skilled in the art would know that the motor can be other forms of pneumatic motors, and although the above embodiment of the two-stage gear motor achieves, through the length relationship between the motor gears, the same rotating speed delivered from the first motor stage and the second motor stage to the power output main shaft, and then achieves the forward joining of the powers of the two motor stages, those skilled in the art would know achieving the same rotating speed delivered from the two gear motor stages to the power output main shaft through changing the modulus or the number of teeth of the motor gears, or through changing both the modulus and the

number of teeth of the motor gears; in addition, a gear shift mechanism can be used to achieve the same rotating speed delivered from the two gear motor stages to the power output main shaft, and then to achieve the objects of the present invention.

[0025] Embodiment 2: Figs. 2 and 3 illustrate the structure of a three-stage pneumatic gear motor according to the present invention, and the three-stage pneumatic gear motor comprises a shell 1 and a power output main shaft 2, and the shell 1 is provided with a gas inlet 3 and a gas outlet 4, characterized in that, the shell 1 is provided therein with three pneumatic gear motor stages, i.e., a first pneumatic gear motor stage 11 consisting of a pair of a first-stage motor gear 111, a second pneumatic gear motor stage 12 consisting of a pair of a second-stage motor gear 121 and a third pneumatic gear motor stage 13 consisting of a pair of a third-stage motor gear 131, the first pneumatic gear motor stage 11 is communicated with the gas inlet 3, the last pneumatic gear motor stage, i.e., the third pneumatic gear motor stage 13, is communicated with the gas outlet 4, and a power gas enters the shell 1 through the gas inlet 3 and then drives the first pneumatic gear motor stage 11 and then the second pneumatic gear motor stage 12, and then the rest one by one, is finally discharged out of the shell 1 through the gas outlet 4 after passing the third pneumatic gear motor stage 13, the first pneumatic gear motor stage 11 is provided with a power output shaft 112, the second pneumatic gear motor stage 12 is provided with a power output shaft 122, the third pneumatic gear motor stage 13 is provided with a power output shaft 132, the power output shaft 112 of the first pneumatic gear motor stage 11, the power output shaft 122 of the second pneumatic gear motor stage 12 and the power output shaft 132 of the third pneumatic gear motor stage 13 are connected with the power output main shaft 2, so that the powers produced by the respective pneumatic gear motor stages are joined together and then output by the power output main shaft 2. Thus, the energy of the compressed gas is fully used, and the efficiency of the pneumatic motor is improved; and the speed and the pressure of the discharged gas are lowered, and the noise of the pneumatic motor is decreased.

[0026] Preferably, as shown in Figs. 2 and 3, the first pneumatic motor stage 11, the second pneumatic motor stage 12 and the third pneumatic motor stage 13 surround the power output main shaft 2 and are arranged in a circular shape, the power output main shaft 2 is located at the centre of the respective pneumatic motor stages, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, and the power output shafts of the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage are connected with the power output main shaft 2 through a transmission gear. In this embodiment, the transmission gear comprises a driving gear 113, 123, 133 provided on the power output shaft 112, 122, 132 of each pneumatic motor stage and a driv-

en gear 21 provided on the power output main shaft 2 while engaging with the driving gear 113, 123, 133 of each pneumatic motor stage. Furthermore, the driving gear 113, 123, 133 can be formed together with the power output shaft of each pneumatic motor stage, so that the power output shaft of each pneumatic motor stage becomes a driving gear shaft, and the driving gears 113, 123, 133 on the driving gear shafts of respective motor stages have the same the modulus and the same number of teeth.

[0027] Under this structure and the arranging manner of the respective motor stages, to achieve the same rotating speed delivered from the each pneumatic motor stage to the power output main shaft, it is only necessary to achieve the same rotating speed of the power output shaft of each stage, thus, the same rotating speed of the power output shafts of the respective motor stages can be achieved by setting the number of teeth and the length of the first-stage motor gear 111, the second-stage motor gear 121 and the third-stage motor gear 131 to be the same and by increasing the modulus of the gears stage by stage. As for the specific ratio relationship between the gear modulus of the respective motor gear stages 111, 121, 131, it can be rendered via simple mathematic calculation according to the inverse proportion relationship between the pressure and the volume of the power gas and the pressure value of the power gas passing each motor stage, and this could be calculated by those skilled in the art and thus is omitted herein.

[0028] Embodiment 3: it is also a three-stage pneumatic gear motor arranged in a circular shape, and its structure and the arranging manner of the respective motor stages are the same with those shown in Figs. 2 and 3, the transmission and connection relationship between the power output shafts of the respective pneumatic motor stages and the power output main shaft is the same with the above embodiment 2, while, a difference, compared with embodiment 2, lies in the manner of achieving the same rotating speed of the power output shaft of each pneumatic gear motor stage, and embodiment 3 achieves the same rotating speed of the power output shafts of the respective motor stages by setting the modulus and the number of teeth of the first-stage motor gear 111, the second-stage motor gear 121 and the second-stage motor gear 131 to be the same and by increasing the lengths of the gears stage by stage. Likewise, the specific ratio relationship between the gear lengths of the respective motor gear stages 111, 121, 131 can be rendered via simple mathematic calculation according to the inverse proportion relationship between the pressure and the volume of the power gas and the pressure value of the power gas passing each motor stage.

[0029] Embodiment 4: it is also a three-stage pneumatic gear motor arranged in a circular shape, and its structure and the arranging manner of the respective motor stages are the same with those shown in Figs. 2 and 3, the transmission and connection relationship between the power output shafts of the respective pneumatic mo-

tor stages and the power output main shaft is the same with the above embodiment 2, while, a difference, compared with embodiment 2, lies in the manner of achieving the same rotating speed of the power output shaft of each pneumatic gear motor stage, and embodiment 4 achieves the same rotating speed of the power output shafts of the respective motor stages by setting the modulus and the gear lengths of the first-stage motor gear 111, the second-stage motor gear 121 and the third-stage motor gear 131 to be the same and by increasing the numbers of the teeth of the gears stage by stage. Likewise, the specific ratio relationship between the numbers of the teeth of the respective motor gear stages 111, 121, 131 can be rendered via simple mathematic calculation according to the inverse proportion relationship between the pressure and the volume of the power gas and the pressure value of the power gas passing each motor stage.

[0030] Although the above embodiments 2, 3 and 4 describe the pneumatic gear motor, those skilled in the art would know that the motor can be other forms of pneumatic motors; although the above embodiments of the three-stage gear motor achieve the same rotating speed delivered from the respective motor stages to the power output main shaft and then achieve the forward joining of the powers of the respective motor stages, through adjusting the rotating speeds of the power output shafts of the respective gear motor stages to be the same and through the driving gears with the same modulus and the same number of teeth, those skilled in the art would know achieving the same rotating speed delivered from the three gear motor stages to the power output main shaft through other adjusting and transmitting manners, and then to achieve the objects of the present invention, and the following embodiment 8 is one of the implementation manners.

[0031] Embodiment 5: Figs. 4 and 5 illustrate the structure of a three-stage pneumatic gear motor according to the present invention, and the three-stage pneumatic gear motor comprises a shell 1 and a power output main shaft 2, and the shell 1 is provided with a gas inlet 3 and a gas outlet 4, characterized in that, the shell 1 is provided therein with three pneumatic gear motor stages, i.e., a first pneumatic gear motor stage 11 consisting of a pair of a first-stage motor gear 111, a second pneumatic gear motor stage 12 consisting of a pair of a second-stage motor gear 121 and a third pneumatic gear motor stage 13 consisting of a pair of a third-stage motor gear 131, the first pneumatic gear motor stage 11 is communicated with the gas inlet 3, the last pneumatic gear motor stage, i.e., the third pneumatic gear motor stage 13, is communicated with the gas outlet 4, and a power gas enters the shell 1 through the gas inlet 3 and then drives the first pneumatic gear motor stage 11 and then the second pneumatic gear motor stage 12, and then the rest one by one, is finally discharged out of the shell 1 through the gas outlet 4 after passing the third pneumatic gear motor stage 13, the first pneumatic gear motor stage 11 is pro-

vided with a power output shaft 112, the second pneumatic gear motor stage 12 is provided with a power output shaft 122, the third pneumatic gear motor stage 13 is provided with a power output shaft 132, the power output shaft 112 of the first pneumatic gear motor stage 11, the power output shaft 122 of the second pneumatic gear motor stage 12 and the power output shaft 132 of the third pneumatic gear motor stage 13 are connected with the power output main shaft 2, so that the powers produced by the respective pneumatic gear motor stages are joined together and then output by the power output main shaft 2. Thus, the energy of the power gas is fully used, and the efficiency of the pneumatic motor is improved; and the speed and the pressure of the discharged gas are lowered, and the noise of the pneumatic motor is decreased.

[0032] As shown in Figs. 4 and 5, the first pneumatic motor stage 11, the second pneumatic motor stage 12 and the third pneumatic motor stage 13 are arranged in a linear shape, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, the power output shafts 112, 122, 132 of the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage are connected with the power output main shaft 2 through a transmission gear, and the transmission gear comprises three first-stage driving gears 113, 123, 133 provided on the power output shafts 112, 122, 132 of each pneumatic motor stage, two first-stage driven gears 61, 62 simultaneously engaging with the first-stage driving gears of the adjacent pneumatic motor stages, two second-stage driving gear shafts 71, 72 being respectively coaxial with the two first-stage driven gears 61, 62, and one second-stage driven gear 21 simultaneously engaging with the two second-stage driving gear shafts 71, 72, and the one second-stage driven gear 21 is provided on the power output main shaft 2. Preferably, the three first-stage driving gears 113, 123, 133 have the same modulus and the same number of teeth, the two first-stage driven gears 61, 62 have the same modulus and the same number of teeth, and the two second-stage driving gear shafts 71, 72 have the same modulus and the same number of teeth.

[0033] Under this structure and the arranging manner of the respective motor stages, to achieve the same rotating speed finally delivered from the power output shafts 112, 122, 132 of the respective pneumatic motor stages to the power output main shaft 2, it is only necessary to achieve the same rotating speed of the power output shafts 112, 122, 132 of the respective stages. Thus, the same rotating speed of the power output shafts of the respective motor stages can be achieved by setting the number of teeth and the length of the first-stage motor gear 111, the second-stage motor gear 121 and the third-stage motor gear 131 to be the same and by increasing the modulus of the gears stage by stage. As for the specific ratio relationship between the gear modulus of the respective motor gear stages 111, 121, 131, it can be

rendered via simple mathematic calculation according to the inverse proportion relationship between the pressure and the volume of the power gas and the pressure value of the power gas passing each motor stage, and this could be calculated by those skilled in the art. Embodiment 6: it is also a three-stage pneumatic gear motor arranged in a linear shape, and its structure and the arranging manner of the three motor stages are the same with those shown in Figs. 4 and 5, the transmission and connection relationship between the power output shafts of the respective pneumatic motor stages and the power output main shaft is the same with the above embodiment 5, while, a difference, compared with embodiment 5, lies in the manner of achieving the same rotating speed of the power output shaft of each pneumatic gear motor stage, and embodiment 6 achieves the same rotating speed of the power output shafts of the respective motor stages by setting the modulus and the number of teeth of the first-stage motor gear 111, the second-stage motor gear 121 and the third-stage motor gear 131 to be the same and by increasing the gear lengths stage by stage. Likewise, the specific ratio relationship between the gear lengths of the respective motor gear stages 111, 121, 131 can be rendered via simple mathematic calculation according to the inverse proportion relationship between the pressure and the volume of the power gas and the pressure value of the power gas passing each motor stage.

[0034] Embodiment 7: it is also a three-stage pneumatic gear motor arranged in a linear shape, and its structure and the arranging manner of the three motor stages are the same with those shown in Figs. 4 and 5, the transmission and connection relationship between the power output shafts of the respective pneumatic motor stages and the power output main shaft is the same with the above embodiment 5, while, a difference, compared with embodiment 5, lies in the manner of achieving the same rotating speed of the power output shaft of each pneumatic gear motor stage, and embodiment 7 achieves the same rotating speed of the power output shafts of the respective motor stages by setting the modulus and the gear lengths of the first-stage motor gear 111, the second-stage motor gear 121 and the third-stage motor gear 131 to be the same and by increasing the numbers of the teeth stage by stage. Likewise, the specific ratio relationship between the numbers of the teeth of the respective motor gear stages 111, 121, 131 can be rendered via simple mathematic calculation according to the inverse proportion relationship between the pressure and the volume of the power gas and the pressure value of the power gas passing each motor stage.

[0035] Although the above embodiments 5, 6 and 7 describe the pneumatic gear motor, those skilled in the art would know that the motor can be other forms of pneumatic motors; although the above embodiments of the three-stage gear motor achieve the same rotating speed delivered from the respective motor stages to the power

output main shaft and then achieve the forward joining of the powers of the respective motor stages, through adjusting the rotating speeds of the power output shafts of the respective gear motor stages to be the same and through the connection manner of the transmission gear, those skilled in the art would know achieving the same rotating speed delivered from the three gear motor stages to the power output main shaft through other adjusting manners and transmitting manners, and then to achieve the objects of the present invention.

[0036] Embodiment 8: this embodiment is a three-stage pneumatic gear motor arranged in a circular shape, and the arrangement of the respective pneumatic motor stages is the same with those shown in Figs. 2 and 3, that is, the respective pneumatic motor stages surround the power output main shaft and are arranged in a circular shape, and the power output main shaft is located at the centre of the respective motor stages. Being different from the above embodiment 2, the transmission gear comprises respective transmission gears of the respective motor gear stages with different reduction ratios and a driven gear 21 provided at the power output main shaft 2, and thus the same rotating speed delivered from the respective pneumatic motor stages to the power output main shaft 2 is achieved, thereby achieving the invention objects of the present invention. In this embodiment, it can be set that the last transmission gears of the respective pneumatic motor stages have the same modulus and the same number of teeth or different numbers of teeth, and in this way, the last one of the respective transmission gears of the respective motor gear stages with different reduction ratios can engage with the driven gear 21 at the output main shaft 2. When the last transmission gears have the same number of teeth, the rotating speeds of the respective motor gear stages have been adjusted to be the same through the respective transmission gears with different reduction ratios before the last transmission gears; when the last transmission gears have different numbers of teeth, the rotating speeds of the respective motor gear stages have not been adjusted to be the same through the respective transmission gears with different reduction ratios before the last transmission gears, and the rotating speeds delivered to the output main shaft 2 must be adjusted to be the same through the relationship between the numbers of the teeth of the last transmission gears. The two transmission and speed adjustment manners can both achieve the object of achieving the same rotating speed delivered from the respective pneumatic motor stages to the output main shaft 2.

Industrial Applicability

[0037] The above embodiments of the present invention can all improve the overall efficiency of the pneumatic motor, save energy, lower the noise, and then achieve the objects of the present invention.

[0038] Described above are merely preferred embod-

iments of the present invention and are not intended to limit the present invention. For those skilled in the art, the present invention may have various alterations and changes. Any alterations, equivalent substitutions, improvements and etc. made within the spirit and principle of the present invention should be covered in the scope of protection of the present invention.

Claims

1. A multistage pneumatic motor, comprising a shell and a power output main shaft, and the shell being provided with a gas inlet and a gas outlet, **characterized in that**, two or more pneumatic motor stages are installed in the shell, the first pneumatic motor stage among the two or more pneumatic motor stages is communicated with the gas inlet, and the last pneumatic motor stage is communicated with the gas outlet, a power gas enters the shell through the gas inlet, drives the first pneumatic motor stage and then the second pneumatic motor stage, then drives the next pneumatic motor stage, and is exhausted from the shell through the gas outlet at last, every pneumatic motor stage is provided with a power output shaft which is connected to the power output main shaft, so that the powers produced by all the pneumatic motor stages are jointed together and then output by the power output main shaft.
2. The multistage pneumatic motor according to claim 1, **characterized in that**, the rotating speeds delivered from the power output shafts of each stage of the pneumatic motor to the power output main shaft are the same, so that the powers produced by each stage of the pneumatic motor are joined forwardly and then outputted by the power output main shaft.
3. The multistage pneumatic motor according to claim 2, **characterized in that**, the pneumatic motor is a gear motor, a vane motor, a plunger motor or a screw motor.
4. The multistage pneumatic motor according to claim 3, **characterized in that**, when the pneumatic motor is a gear motor, the shell is provided therein with a first pneumatic motor stage consisting of a pair of a first-stage motor gear and a second pneumatic motor stage consisting of a pair of a second-stage motor gear, one gear shaft of the first-stage motor gears is the power output shaft of the first pneumatic motor stage, one gear shaft of the second-stage motor gears is the power output shaft of the second pneumatic motor stage, the power output shaft of the first pneumatic motor stage, the power output shaft of the second pneumatic motor stage and the power output main shaft are the same shaft, the first-stage motor gear and the second-stage motor gear have

the same number of teeth and the same modulus, and the first-stage motor gear is shorter than the second-stage motor gear, so that the rotating speed of the power output shaft of the first pneumatic motor stage is the same with the rotating speed of the power output shaft of the second pneumatic motor stage.

5. The multistage pneumatic motor according to claim 3, **characterized in that**, when the pneumatic motor is a gear motor, the shell is provided therein with a first pneumatic motor stage consisting of a pair of a first-stage motor gear, a second pneumatic motor stage consisting of a pair of a second-stage motor gear and a third pneumatic motor stage consisting of a pair of a third-stage motor gear, and the power output shafts of the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage are connected with the power output main shaft through a transmission gear.
6. The multistage pneumatic motor according to claim 5, **characterized in that**, the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage surround the power output main shaft and are arranged in a circular shape, the power output main shaft is located at the centre of the respective pneumatic motor stages, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, and the transmission gear comprises a driving gear provided on the power output shaft of each pneumatic motor stage and a driven gear provided on the power output main shaft while engaging with the driving gear of each pneumatic motor stage.
7. The multistage pneumatic motor according to claim 6, **characterized in that**, the driving gear provided on the power output shaft of each pneumatic motor stage is a gear formed on the power output shaft, so that the power output shaft of each pneumatic motor stage becomes a driving gear shaft, and the driving gears on the driving gear shafts of respective pneumatic motor stages have the same the modulus and the same number of teeth.
8. The multistage pneumatic motor according to claim 5, **characterized in that**, the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage are arranged in a linear shape, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, the transmission gear comprises three first-stage driving gears provided on the power output shaft of each pneumatic motor stage, two first-stage driven gears simultaneously engaging with the first-stage driving gears of the adjacent pneumatic motor stages, two second-stage driving gear shafts being respectively coaxial with the two first-stage

driven gears, and one second-stage driven gear simultaneously engaging with the two second-stage driving gear shafts, and the one second-stage driven gear is provided on the power output main shaft.

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9. The multistage pneumatic motor according to claim 8, **characterized in that**, the three first-stage driving gears have the same modulus and the same number of teeth, the two first-stage driven gears have the same modulus and the same number of teeth, and the two second-stage driving gear shafts have the same modulus and the same number of teeth. 10
10. The multistage pneumatic motor according to claim 7 or 9, **characterized in that**, the first-stage motor gear, the second-stage motor gear and the third-stage motor gear have the same number of teeth and the same gear length, and the modulus of the gears increase stage by stage so that the rotating speeds of the power output shafts of the respective pneumatic motor stages are the same. 15 20
11. The multistage pneumatic motor according to claim 7 or 9, **characterized in that**, the first-stage motor gear, the second-stage motor gear and the third-stage motor gear have the same number of teeth and the same modulus, and the lengths of the gears increase stage by stage so that the rotating speeds of the power output shafts of the respective pneumatic motor stages are the same. 25 30
12. The multistage pneumatic motor according to claim 7 or 9, **characterized in that**, the first-stage motor gear, the second-stage motor gear and the third-stage motor gear have the same modulus and the same gear length, and the numbers of the teeth of the gears increase stage by stage so that the rotating speeds of the power output shafts of the respective pneumatic motor stages are the same. 35 40
13. The multistage pneumatic motor according to claim 5, **characterized in that**, the first pneumatic motor stage, the second pneumatic motor stage and the third pneumatic motor stage surround the power output main shaft and are arranged in a circular shape, the power output main shaft is located at the centre of the respective pneumatic motor stages, one gear shaft of each pair of motor gear stages is the power output shaft of each pneumatic motor stage, the transmission gear comprises respective transmission gears of the respective motor gear stages with different reduction ratios and a driven gear provided at the power output main shaft, and the rotating speeds delivered from the respective pneumatic motor stages to the power output main shaft are the same. 45 50 55

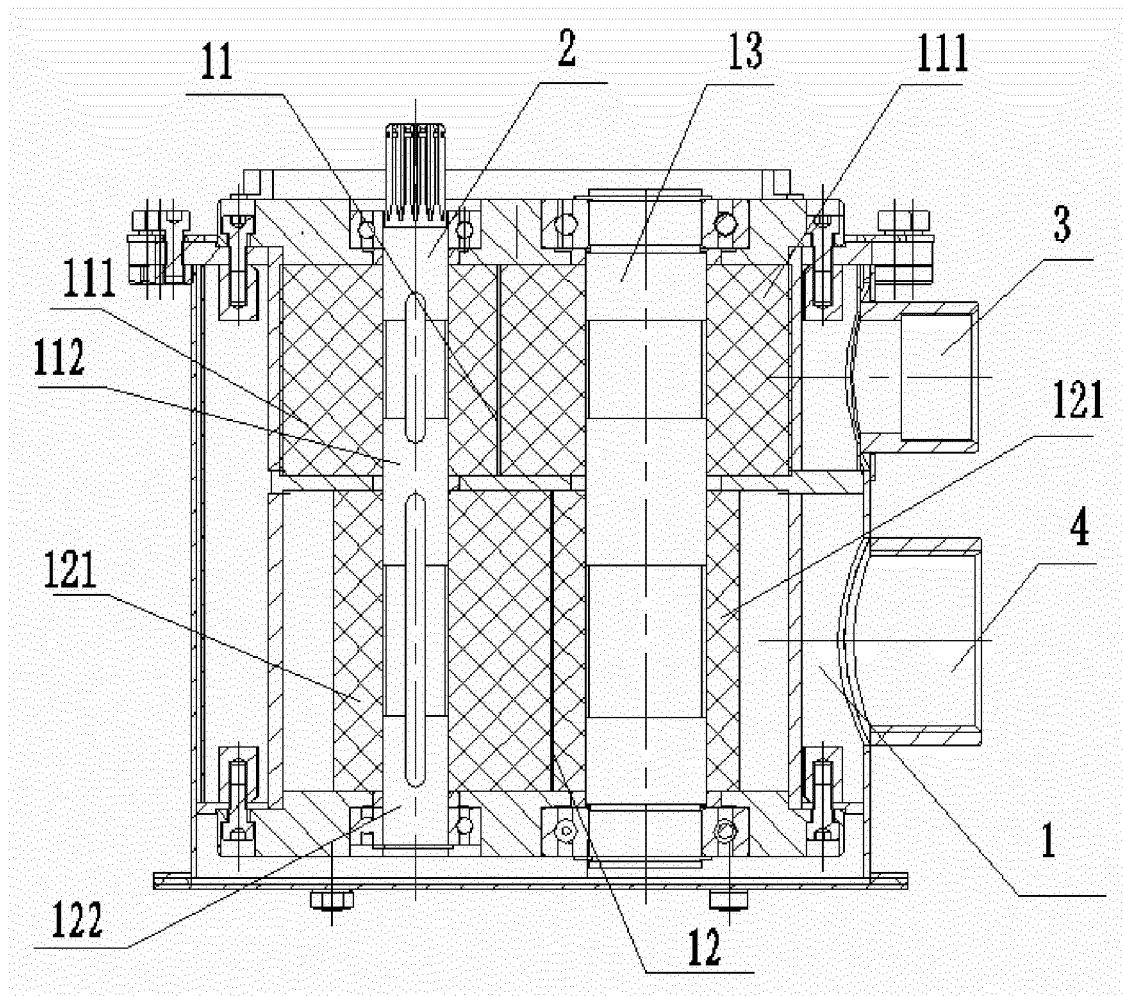


Fig. 1

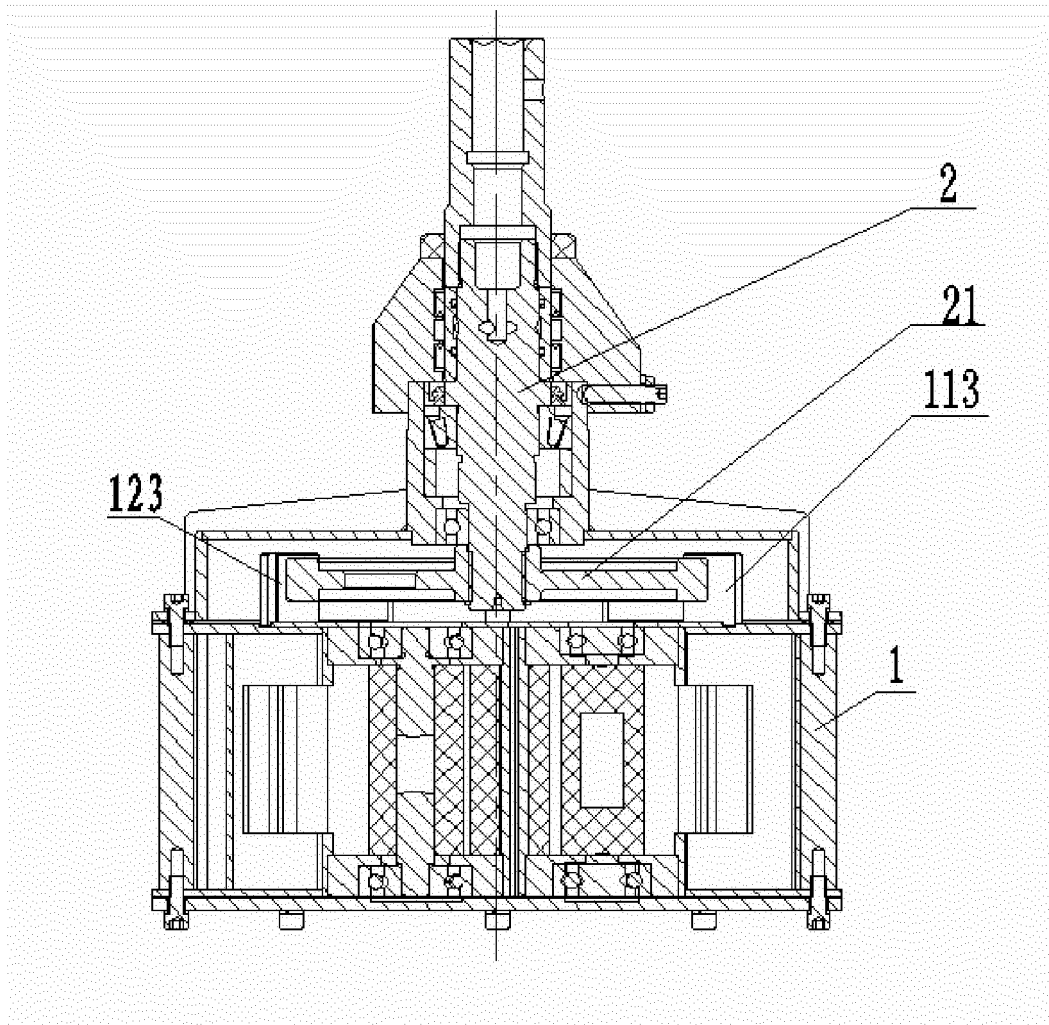


Fig. 2

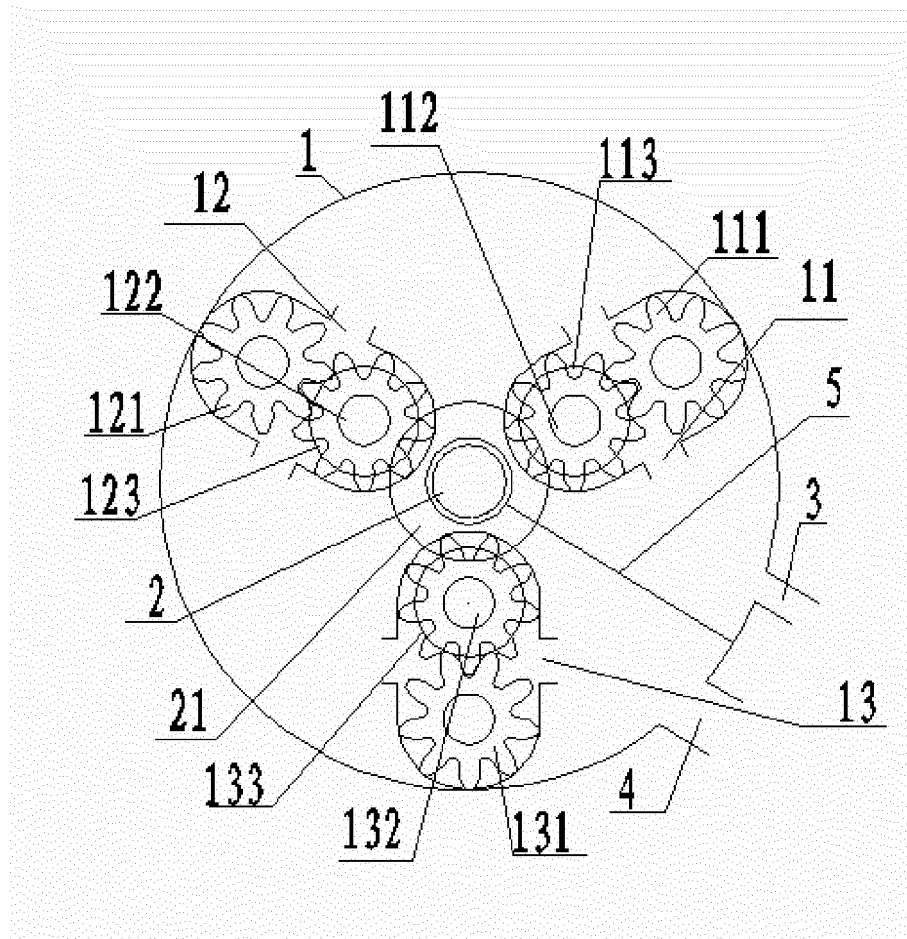


Fig. 3

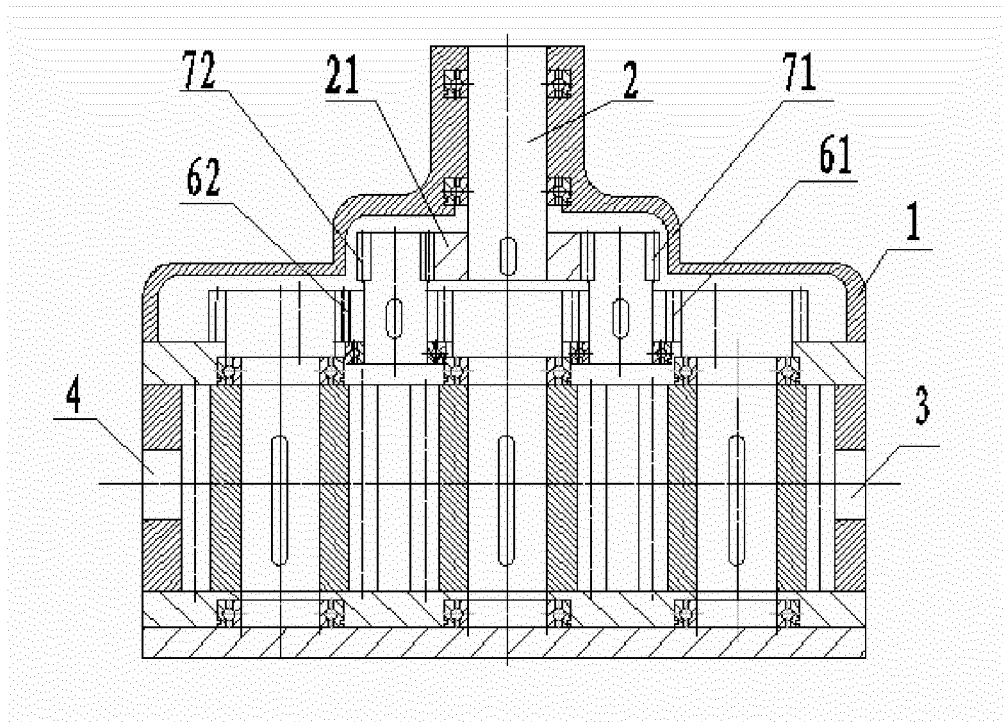


Fig. 4

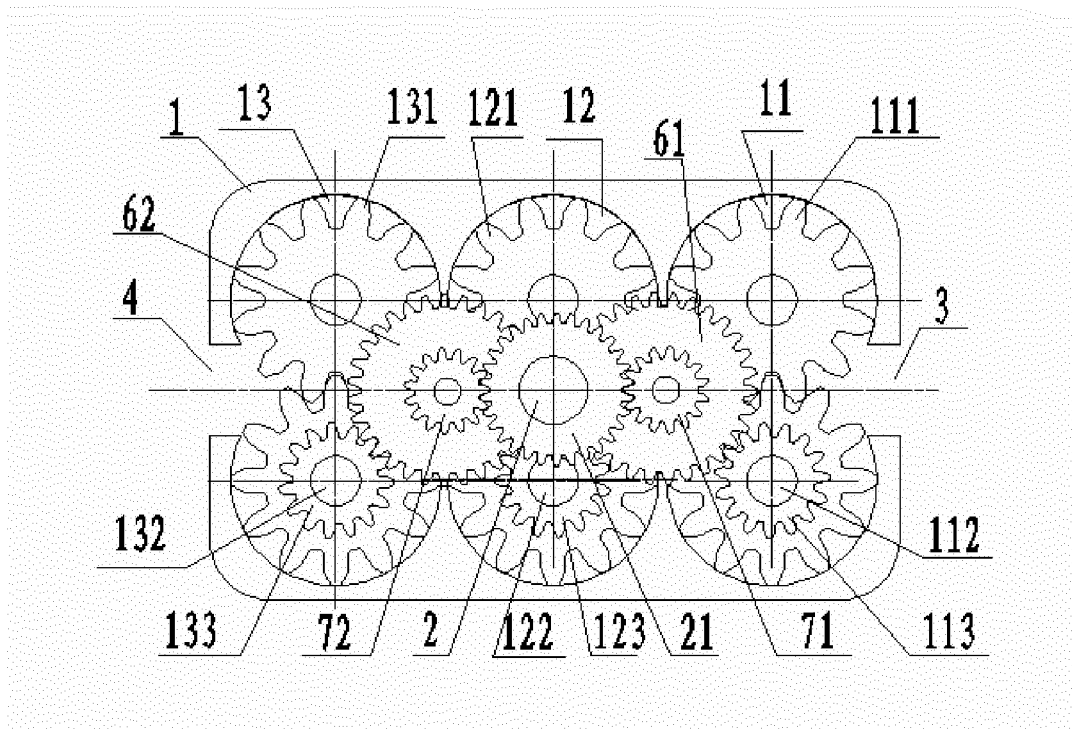


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2010/078715

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F01C, F04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, CNPAT, CNKI; pneumatic, motor, compressed gas, air, gear, series, multi, two, more, stage, level

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	CN101852091A (SHIJIAZHUANG ZHONGMEI COAL MINE EQUIPMENT MANUFACTURE CO., LTD.)06 Oct. 2010(06.10.2010) paragraphs 3-22 of the description, figs. 1-3	1-13
E	CN201696097U(SHIJIAZHUANG ZHONGMEI COAL MINE EQUIPMENT MANUFACTURE CO., LTD.)05 Jan. 2011(05.01.2011)paragraphs 3-22 of the description, figs. 1-3	1
X	GB999459A (ERICH MARTIN)28 Jul. 1965(28.07.1965) pages 2-6 of the description, figs. 1-8	1
A	US2631428A (ARTHUR H NELSON et al.)17 Mar.1953(17.03.1953) the whole document	1-13
A	CN2702088Y (ZHU Miaorui)25 May 2005(25.05.2005)the whole document	1-13

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&”document member of the same patent family

Date of the actual completion of the international search
10 Feb. 2011(10.02.2011)Date of mailing of the international search report
24 Feb. 2011 (24.02.2011)Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
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100088
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2010/078715

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101852091A	06.10.2010	NONE	
CN201696097U	05.01.2011	NONE	
GB999459A	28.07.1965	BE616664A1	16.08.1962
		US3214907A	02.11.1965
US2631428A	17.03.1953	NONE	
CN2702088Y	25.05.2005	NONE	

Form PCT/ISA/210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2010/078715

A. CLASSIFICATION OF SUBJECT MATTER

F01C 11/00(2006.01)i

F04C 11/00(2006.01)i