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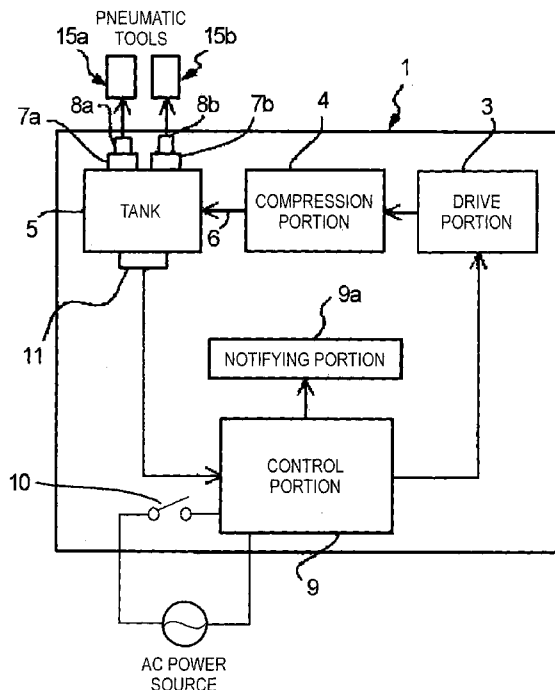
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(54) Title: AIR COMPRESSOR

FIG. 1



(57) Abstract: An air compressor (1) includes a compression portion (4), a drive portion (3) for driving the compression portion (4), a tank (5) for storing compressed air, a pressure sensor (11) for monitoring a pressure of the compressed air stored in the tank (5), a control portion (9) for storing reference data expressing a relationship between a tank internal pressure when quantity of drain accumulated in the tank (4) has reached a predetermined value and an operating time of the drive portion (3) and for receiving pressure information from the pressure sensor and information about the operating time of the drive portion (3), and a notifying portion (9a) controlled by the control portion (9) for outputting a notifying signal. The control portion (9) compares measured data of the pressure information and the operating time information with the reference data and operates the notifying portion (9a) when tank internal drain accumulation quantity has reached the predetermined value.



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DESCRIPTION

Title of Invention

AIR COMPRESSOR

Technical Field

The invention relates to an air compressor, especially to the enhancement of the working efficiency of a portable air compressor.

Background Art

In a building site and the like, there is used a portable pneumatic tool which drives a nail or a screw into a timber or the like using the pressure of compressed air. In a portable pneumatic tool for use indoors and outdoors, the air pressure of compressed air generated by a portable air compressor is adjusted to proper pressure by a pressure reducing valve mounted on an air tank and is supplied through an air hose to the pneumatic tool, where the air pressure is converted to power, thereby allowing the tool to drive a nail or a screw.

The air compressor compresses air using the compressing operation of a piston and stores the compressed air in an air tank. However, when the air compressor is used for a long time, a moisture component of the compressed air accumulates as drain in the air tank to reduce the capacity of the air tank and thus the capacity of the air to be taken out from the air tank, thereby degrading the working efficiency of the air compressor.

Also, when the discharge of the drain is left for a long time, the drain flows out toward the pneumatic tool to thereby shorten the life of the pneumatic tool.

Therefore, an operator, at the end of a day's work, exhausts the pressure remaining in the air tank and simultaneously discharges the drain to the outside of the air tank using a drain discharge cock provided on the air tank.

Citation List

Patent Literature

PTL 1: Japanese Patent No. 4009949

Summary of Invention

Technical Problem

However, in the above-cited air compressor, the drain accumulated in the air tank cannot be observed from the outside. Therefore, when, at the end of the operation, the residual pressure of the air tank is used to clean the tool and its environment by an air gun or the like, it is reduced down to the level that cannot discharge the accumulated drain sufficiently; and thus, even when the drain remains, the operator cannot be aware of the remaining drain. Also, under a highly humid working environment, since the accumulating time of the drain quickens, the drain accumulates earlier than expected, raising a fear that the drain can overflow to the tool.

Therefore, in order to notify the operator of the drain accumulated in the tank, it is necessary to detect quantity of the drain and convert it to a signal serving as means that can be recognized by the operator. However, this requires a specific sensor or detecting device, resulting in the increased cost of the air compressor.

Solution to Problem

The invention is made in view of the above problems found in the

conventional background. Thus, illustrative aspects of the invention provide an air compressor which, focusing attention on the fact that, when drain accumulates in a tank, the capacity of the tank is reduced to thereby shorten the time necessary for increasing the pressure of the tank, can detect and notify that predetermined quantity of drain (for example, use limit drain quantity) has accumulated in the tank, with a simple and inexpensive structure.

According to one illustrative aspect of the invention, there is provided an air compressor comprising: a compression portion configured to generate compressed air; a drive portion configured to drive the compression portion; a tank for storing the compressed air; a pressure sensor configured to detect a pressure of the compressed air stored in the tank; a control portion configured to store reference data expressing the relationship between the pressure of compressed air in the tank and an operating time of the drive portion and to receive pressure information from the pressure sensor; and a notifying portion controlled by the control portion for outputting a notifying signal, wherein the control portion is configured to: compare measured data of the pressure information from the pressure sensor and the operating time information of the drive portion with the reference data; and operate the notifying portion to output the notifying signal in a case where it is determined that quantity of drain accumulated in the tank has reached a predetermined value.

According to another illustrative aspect of the invention, there is provided an air compressor comprising: a compression portion configured to generate compressed air; a drive portion configured to drive the compression portion; a tank for storing the compressed air; a pressure sensor configured to detect a pressure of the compressed air stored in the tank; a control portion configured to store reference data expressing a relationship between the pressure of compressed air in the tank and an operating time

of the drive portion and to receive pressure information from the pressure sensor; and a notifying portion controlled by the control portion for outputting a notifying signal, wherein the control portion is configured to operate the notifying portion in a case where a pressure increase rate of the compressed air in the tank in measured data is equal to or higher than a pressure increase rate of the compressed air in the tank in the reference data.

Here, arbitrary combinations of the above composing elements of the invention are also effective as modes for carrying out the invention. And, when the invention is changed with respect to the method and system thereof, such changes are also effective as modes for carrying out the invention.

Advantageous Effects of the Invention

According to the air compressor of the invention, when predetermined quantity of drain or more has accumulated in the tank, it is possible to notify an operator of the need for discharge of the drain, thereby being able to prevent the degraded working efficiency caused by the residual drain and thus the shortened life of a tip pneumatic tool.

Brief Description of the Drawings

[Fig. 1] Fig. 1 is a function block diagram of an embodiment of an air compressor according to the invention.

[Fig. 2] Fig. 2 is a partially sectional side view of the embodiment.

[Fig. 3] Fig. 3 is a partially sectional plan view of the embodiment.

[Fig. 4] Fig. 4 is a partially sectional front view of the embodiment.

[Fig. 5] Fig. 5 is a sectional plan view of a compression portion included in

the embodiment.

[Fig. 6] Fig. 6 is a graph of tank internal pressure changes in the embodiment, explaining a basic first operation example for detecting the use limit of drain accumulation quantity.

[Fig. 7] Fig. 7 is a flow chart of the basic first operation example for detecting the use limit of the drain accumulation quantity.

[Fig. 8] Fig. 8 is a graph of tank internal pressure changes in the embodiment, explaining a second operation example for detecting the use limit of the drain accumulation quantity.

[Fig. 9] Fig. 9 is a graph of tank internal pressure changes in the embodiment, explaining a third operation example for detecting the use limit of the drain accumulation quantity in the embodiment.

[Fig. 10] Fig. 10 is a graph of tank internal pressure changes in the embodiment, explaining a fourth operation example for detecting the use limit of the drain collection quantity in the embodiment.

[Fig. 11] Fig. 11 is a function block diagram of another embodiment of an air compressor according to the invention.

Description of Embodiments

Now, description will be given specifically of a preferred embodiment of the invention with reference to the accompanying drawings. Here, the same or equivalent composing elements, members, processes and the like shown in the respective drawings are given the same designations and thus the duplicate description thereof is omitted. Also, the embodiment does not limit the invention but is just an example of the invention, while all characteristics described in the embodiment and combinations

thereof are not always the essence of the invention.

Referring to Figs. 1 to 4, description will be given of the whole structure of a portable air compressor according to the embodiment of the invention. In these figures, a portable air compressor 1 includes an air tank 5 for storing compressed air, a pressure sensor 11 for detecting (monitoring) the pressure of the compressed air in the tank 5, a compression portion 4 for generating compressed air, a drive portion 3 for driving the compression portion 4, a main power switch 10, a control portion 9 for controlling the start/stop (on/off) of the drive portion 3, and a notifying portion 9a.

The main power switch 10 is used to turn on and off commercial AC power to be supplied to the air compressor 1. The AC power supplied through the main power switch 10 is converted to DC power by the control portion 9 and is used as the drive power of the drive portion 3 and the like.

The drive portion 3 includes an electric motor such as a DC brushless motor, while the drive circuit (an inverter circuit (not shown)) of the motor is controlled by the control portion 9. That is, the turn on/off control (rotation control) of the motor of the drive portion 3 is carried out by the control portion 9.

The control portion 9 includes a microcomputer (not shown) which contains circuit function blocks: for example, a central processing unit (CPU) for executing an operation and a control program; a read only memory (ROM) for storing the control program of CPU and the like; and, a random access memory (RAM) used as the work area, temporary memory area and the like of CPU.

As shown in Fig. 1, the CPU of the control portion 9 receives a compressed air pressure detection signal from the pressure sensor 11 mounted on the tank 5, and controls the drive portion 3, that is, starts (turns on) or stops (turns off) the drive portion 9. Also, the control portion 9 has a function to control the notifying portion

9a to notify an operator of the accumulation degree of drain (whether the drain accumulation quantity has reached the use limit or not) (which will be discussed later).

The air tank 5 is constituted of a pair of cylindrical tank bodies arranged side by side and in communication with each other and is used to store compressed air. The compressed air is generated in the compressed portion 4 and is supplied from the discharge opening thereof into the tank 5 through a pipe (an air flow passage) 6. The thus supplied compressed air has a pressure of, for example, 3.0 ~ 4.5 MPa in the tank 5.

A relief valve 5a (see Figs. 2 and 3) is mounted on a portion of the tank 5. When the pressure in the tank 5 becomes abnormally high, a part of the compressed air is discharged to the outside, thereby preventing the pressure from increasing abnormally by any chance. Also, the tank 5 includes a pair of compressed air outlet openings (air sockets) 8a and 8b to which pneumatic tools 15a and 15b (see Fig. 1) such as nailing machines can be connected through air hoses, respectively.

On the air sockets 8a and 8b sides of the tank 5, there are provided pressure reducing valves 7a and 7b respectively having a function to hold the air sockets 8a and 8b side pressure constant at the highest pressure or lower regardless the intensity of the pressure on the entrance side (pipe 6 side) of the tank 5. Therefore, in the air sockets 8a and 8b, regardless of the pressure in the tank 5, there can be obtained the compressed air having pressure equal to or less than the above highest pressure.

Pressure gages 13a and 13b are mounted near the air sockets 8a and 8b, whereby pressure near the air sockets 8a and 8b can be monitored.

The compression portion 4, as shown in Fig. 5, includes cylinders 41a, 41b and pistons 42a, 42b. The rotational movement of the drive portion 3 is transmitted to a crankshaft 50 to thereby rotate a low pressure side crank arm 43a and a high

pressure side crank arm 43b. A high pressure side connecting rod 45b is rotatably provided on the outer periphery of the high pressure side crank arm 43b through a bearing 44b. When the high pressure side connecting rod 45b rotates eccentrically, the rotational movement thereof is converted to the reciprocating movement of the high pressure side piston 42b disposed within the high pressure side cylinder 41b. Similarly, on the outer periphery of the low pressure side crank arm 43a, there is rotatably provided a low pressure side connecting rod 45a through a bearing 44a. When the low pressure side crank arm 43a rotates eccentrically, the rotational movement thereof is converted to the reciprocating movement of the low pressure side piston 42a disposed within the low pressure side cylinder section 41a.

Firstly, in a suction process in which the high pressure side piston 42b and low pressure side piston 42a go down from the top dead centers of the high pressure side cylinder 41b and low pressure side cylinder 41a to the bottom dead centers thereof, the air is sucked into a high pressure side compression chamber 46b and a low pressure side compression chamber 46a. On the other hand, in a step where the high pressure side piston 42b and low pressure side piston 42a rise from the bottom dead centers of the high pressure side cylinder 41b and low pressure side cylinder 41a to the top dead centers thereof, the high pressure side piston 42b and low pressure side piston 42a compress the air within the high pressure side compression chamber 46b and low pressure side compression chamber 46a, thereby generating compressed air. The compressed air, which is generated in a discharge step where the high pressure side piston 42b and low pressure side piston 42a reach the top dead centers of the high pressure side compression chamber 46b and low pressure side compression chamber 46a, is discharged to a pipe (not shown).

The reciprocating movements of the high pressure side piston 42b and low

pressure side piston 42a are out of phase, whereby the compressed air discharged from the low pressure side compression chamber 46a is sucked into the high pressure side compression chamber 46b through a pipe (not shown) and the compressed air discharged from the high pressure side compression chamber 46b is supplied to the tank 5 through a pipe (not shown).

Here, the flow direction of the air is limited to one direction by a suction valve and a discharge valve respectively provided in the high pressure side compression chamber 46b and low pressure side compression chamber 46a. The supplied compressed air, within the tank 5, has the pressure of, for example, about 3.0 ~ 4.5 MPa.

In this case, since the generated compressed air sucks and compresses the air of the atmosphere, moisture contained in the atmosphere is compressed together. After the thus sucked moisture is supplied to the tank 5, it is cooled and is accumulated as water, that is, drain.

As shown in Fig. 2, the tank 5 includes a drain cock 12. This drain cock 12 has on its primary side a tube 51 extended near to the bottom surface of the inside of the tank, while its secondary side is structured such that the primary and secondary sides can be opened and closed by a ball-type valve for releasing the atmosphere. The drain accumulated in the tank 5, when the drain cock 12 is opened, can be discharged to the outside of the tank through the primary side tube 51 and secondary side air releasing ball-type valve using the internal pressure of the tank 5.

By repeating the above suction, compression and discharge steps using the reciprocating movements of the piston sections 42a and 42b, the compression portion 4 can supply to the tank 5 the compressed air having pressure ranging from a first reference pressure (an arbitrary value) to a second reference pressure equal to or less

than the allowable highest pressure. When the internal pressure of the tank 5 reaches the previously set allowable highest pressure (second reference pressure), according to the pressure detection signal of the pressure sensor 11, the control portion 9 transmits a stop signal to the drive portion 3 to stop the operation of the motor of the drive portion 3, thereby causing the rotation of the motor of the drive portion 3 to stop. As a result, the reciprocating movements of the pistons 42a and 42b of the compression portion 4 are stopped and thus the generation of the compressed air is stopped.

The notifying portion 9a (see Fig. 1) is the composing portion that is formed according to the invention, namely, a circuit which, when the drain continues to accumulate to the tank 5 and the quantity thereof reaches the use limit quantity as the result of for long-time execution of the compressing operation, turns on an alarm light such as a light emitting diode (LED) or generates an alarm sound using a buzzer or the like; and, it is controlled by the control portion 9. The operation of the notifying portion 9a is described later. However, as means for notification, there can be used an arbitrary method. For example, a method for providing an alarm light for notification on an operation panel 14 (see Fig. 2); a method for turning on an LED provided on the operation panel 14 for notifying the internal pressure of the tank and the operation condition thereof according to a specific lighting pattern; and, a notifying method using a buzzer or sound.

The present inventors have found that, as shown in the basic first operation example of Fig. 6, as the moisture contained in the compressed air generated in the compression portion 4 accumulates in the tank as drain and the quantity thereof increases, the operating time (charging time) t of the drive portion 3 (or compression portion 4) necessary to raise the pressure of the compressed air in the tank 5 (tank internal pressure) P is reduced from a first reference pressure P_r to a second reference

pressure P_m . Here, for easy understanding, in Fig. 6, it is assumed that the relationship between the operating time and compressed air pressure is linear.

That is, in the operating time t vs. tank internal pressure P characteristics shown in Fig. 6, a characteristic A expresses a pressure increasing characteristic (in the initial time) when no drain exists in the tank 5, and a characteristic B expresses a pressure increasing characteristic (in the drain accumulation quantity limit time) when drain has accumulated up to the limit quantity due to the long-time operation of the drive portion 3.

The present inventors have also found the following problem. That is, as the drain accumulation quantity increases from the characteristic A (in the initial time) to the characteristic B (in the drain accumulation quantity limit time), the operating time (charging time) t of the drive portion 3 for increasing the tank 5 internal compressed air from a first reference pressure P_r (for example, standard atmospheric pressure) up to a second reference pressure (allowable highest pressure, for example, 30 MPa) reduces from T_f to T_m ($T_m < T_f$); and, when the operating time t is shorter than a predetermined time T_m , the drain quantity exceeds the drain accumulation quantity limit and thus the drain flows out to the pneumatic tool, thereby reducing the life of the pneumatic tool.

Thus, in the present embodiment, there is provided the notifying portion 9a which can be controlled by the control portion 9 and, when the drain accumulation quantity reaches the use limit quantity, can notify the need for discharge of the drain. Specifically, the control portion 9 previously stores in the memory section (not shown) thereof reference data expressing the relationship between the tank internal pressure P and the operating time t of the drive portion 3 when the drain accumulation quantity reaches the use limit quantity. The reference data are obtained experimentally with respect to the relationship between the use limit quantity of the drain accumulation

quantity and tank internal pressure. The reference data include the reference operating time T_m of the compression portion 4 (or drive portion 3) necessary to increase the tank internal pressure P from the first reference pressure P_r to the second reference pressure P_m when the drain accumulation quantity reaches the use limit quantity.

In operation, the control portion 9, as shown in the characteristic C of Fig. 6 corresponding to measured data when the air compressor 1 is operated, detects measured data (time T_a or the function of time T_a) expressing the operating time T_a necessary to increase the tank 5 internal pressure P from the first reference pressure P_r to the second reference pressure P_m according to the pressure sensor 11 and the timer function of the control portion 9. And, the measured data (time T_a or the function of time T_a) are compared with the reference data. When the operating time T_a of the measured data reaches the reference operating time T_m of the reference data, the control portion 9 controls the notifying portion 9a (see Fig. 1) to emit a notifying signal notifying visually or audibly that it is time to discharge the drain. For example, the notifying portion 9a, when the relationship of the measured operating time T_a to the reference operating time T_m is $T_a \leq T_m$, drives a buzzer or the like to emit an alarm sound as a notifying signal for notification, or turns on or blink an alarm light such as a light emitting diode as a notifying signal for notification.

Using a flow chart shown in Fig. 7, description will be given of the flow of operations ranging from the start of the operation of the air compressor 1 to the activation of the notifying portion 9a. In Fig. 7, in Step S1, the operation of the air compressor 1 is started (motor on). In Step S2, it is checked whether the tank internal pressure P has reached the first reference pressure (arbitrary value) P_r or not. When it has not reached (No), Step S2 is repeated. When it has reached the first reference

pressure P_r (Yes), in Step S3, the control portion 9 is driven to start the time measurement of a built-in timer (timer is on). In Step S4, it is checked whether the tank internal pressure P has reached the second reference pressure (allowable highest pressure) P_m or not. When it has not reached (No), Step S4 is repeated. When it has reached (Yes), in Step S5, the operation of the air compressor 1 is stopped (motor off) and the time measurement of the timer is stopped (timer off). In Step S6, the measured operating time T_a obtained from the measured value of the timer is compared with the reference operating time T_m stored in the memory section to check whether $T_a \leq T_m$ or not. For $T_a > T_m$ (No), the notifying portion 9a is not operated to provide the “no alarm” state of Step S7. For $T_a \leq T_m$ (Yes), the notifying portion 9a is operated to provide the “alarm raising” state of Step S8 and thus the notifying portion 9a outputs to an operator a notifying signal (a first notifying signal) notifying that it is time to discharge the drain.

Here, to prepare for the case that the operator is not aware of the above alarm, the number of times that the operating time t exceeds the reference data operating time T_m may be previously stored in the memory section of the control portion 9 and, when the number of times reaches a predetermined number of times, the resumption of the operation of the compressor 1 may be prohibited; or, in order to be able to notify the operator of some abnormal conditions, notifying signals may be previously set in multiple stages in such a manner that they can be switched according to the stages, for example, a second notifying signal different from a first notifying signal may be output. After then, when the operator discharges the drain, the operating time t becomes longer than the reference data operating time T_m . On detecting that the operating time t becomes longer than the reference data operating time T_m , the control portion 9 may reset the number of times stored in the memory section.

According to the present embodiment, the following effects can be provided.

(1) Since the reference data expressing the relationship between the pressure P of the compressed air in the tank 5 when the drain accumulation quantity in the tank 5 reaches the use limit and the operating time t of the drive portion 3 for driving the compression portion 4 are previously stored in the control portion 9, by comparing the reference data with the measured data in the air compressor operating time, the control portion 9 can detect that the drain has accumulated in the tank 5 up to the use limit quantity, and can thus drive the notifying portion 9a to notify this visually or audibly. Since the control portion 9 can urge the operator to discharge the drain in this manner, the degraded working efficiency caused by the residual drain and the shortened life of the tip pneumatic tool can be prevented.

(2) By using the pressure sensor 11 which is one of the basic composing parts of the air compressor 1, and by operating the output data of the sensor, the accumulation quantity of drain can be grasped indirectly; and, any other parts need not be added. Thus, the pressure sensor 11 can be used as inexpensive and highly reliable maintenance means.

In the flow chart of Fig. 7, while focusing attention on the time necessary to increase the pressure of the compressed air from the first reference pressure (arbitrary value) P_r to the second reference pressure (allowable highest pressure) P_m in Fig. 6, the use limit of the drain accumulation quantity is determined. However, the drain accumulation quantity use limit may also be determined by focusing attention on the fact that the pressure increase rate with respect to the operating time is larger in the characteristic A (initial time) than in the characteristic B (drain accumulation quantity limit time) in Fig. 6. In this case, the pressure increase rate ($\Delta P_m / \Delta T_m$) in a specific minute time period included in the above-mentioned reference data is used and is

previously stored in the memory section of the control portion 9. This data is compared with the pressure increase rate ($\Delta P_a/\Delta T_a$) of a characteristic C that is measured data in the same minute time period. When $(\Delta P_m/\Delta T_m) \leq (\Delta P_a/\Delta T_a)$, a notifying signal telling that it is time to discharge the drain may be output from the notifying portion 9a in Fig. 1 to the operator. ΔT_m may be a minute time (for example, 3 seconds) or may be a time (for example, 60 seconds) having a predetermined length after the motor is started.

Also, the drain accumulation quantity use limit may also be determined by focusing attention on the fact that the pressure after passage of a predetermined operating time T_c is larger in the characteristic B (drain accumulation quantity limit time) than in the characteristic A (initial time) in Fig. 6. In this case, the pressure P_{cm} of the characteristic B at a time after passage of the predetermined operating time T_c included in the above-mentioned reference data is used and is previously stored in the memory section of the control portion 9. This data is compared with the pressure P_{ca} of the characteristic C that is measured data obtained at the same time. When $P_{cm} \leq P_{ca}$, the notifying portion 9a in Fig. 1 may output to the operator a notifying signal telling that it is time to discharge the drain.

Fig. 6 shows the characteristic A (initial time) and characteristic B (drain accumulation quantity limit time) assuming that the relationship between the operating time and tank internal compressed air pressure is linear. Actually, however, as shown in a second embodiment of Fig. 8, the relationship between the operating time and tank internal compressed air pressure is not perfectly linear. That is, the characteristic A (initial time) and characteristic B (drain accumulation quantity limit time) both tend to reduce in the pressure increase rate as they approach the second reference pressure (allowable highest pressure) P_m .

In the case of Fig. 8 as well, the operation can be executed following the flow chart of Fig. 7. Also, in Fig. 8, the pressure P_{cm} of the characteristic B at a time after passage of the predetermined operating time T_c included in the above-mentioned reference data may be used and may be previously stored in the memory section of the control portion 9. This pressure may be compared with the pressure P_{ca} of the characteristic C that is measured data at the same time. When $P_{cm} \leq P_{ca}$, the notifying portion 9a in Fig. 1 may also output to the operator a notifying signal telling that it is time to discharge the drain water. However, there is a possibility that the difference between the pressure increase rates of the characteristic A (initial time) and characteristic B (drain water storage quantity limit time) in Fig. 8 with respect to the operating time cannot be clear depending on time periods to be measured.

Fig. 9 is a graph of tank internal pressure changes in a third operation example in which pneumatic tools 15a and 15b are connected to the air compressor 1 shown in Fig. 1 and are used intermittently. That is, in actual use of a pneumatic tool, when, as shown in Fig. 9, after the tank internal pressure is raised to the maximum value P_{max} , use of the pneumatic tool is started, with use of the pneumatic tool, the tank internal pressure reduces down to the use limit lower limit value (for example, 2.0 Mpa) of the pneumatic tool. At this time, use of the pneumatic tool is stopped once and an operator waits until the tank internal pressure reaches the maximum value P_{max} . After reaching the maximum value P_{max} , use of the pneumatic tool is started again. This operation cycle is repeated. In the tank internal pressure increasing phases of the respective cycles, by comparing measured times T_{a1} , T_{a2} , T_{a3} , --- necessary to increase the pressure from the first reference pressure P_r up to the second reference pressure P_m with the reference operating time T_m of the memory section, it is possible to detect that a use limit quantity of drain has accumulated in the tank according to Fig.

6 and the operation of the flow chart of Fig. 7 and thus the notifying portion is allowed to notify the operator of this, for example, visually or audibly.

As shown in Fig. 9, in the increasing phases of the tank internal pressure P of the respective cycles, by checking whether a use limit quantity of drain has accumulated in the tank or not, it is possible to notify the operator of the drain discharge timing more quickly.

Fig. 10 shows a fourth operation example of the air compressor 1 in which, in consideration of the fact that the pressure detected by the pressure sensor 11 of Fig. 1 is affected by the pressure return $+\Delta P$ due to the inertia effect of the air within the tank, the use limit drain quantity within the tank is detected while avoiding the wrong detection caused by the pressure return $+\Delta P$.

First, description will be given of a case where the wrong detection occurs. In the case that the tank internal use limit drain quantity is detected similarly to Fig. 9 according to the measured time necessary for the pressure to reach the second reference pressure P_m from the first reference pressure P_r , when the consumption of the air ends at a pressure slightly lower than the first reference pressure P_r , like a waveform J shown in a central part of Fig. 10, under the influence of the pressure return $+\Delta P$ due to the inertia effect of the air within the tank, the tank internal pressure increases suddenly from the first reference pressure P_r toward the second reference pressure P_m . Therefore, a boosting time $Ta2'$ from the first reference pressure P_r to the second reference pressure P_m is detected as a short time. In other words, $Ta2' < Ta2$ (described in Fig. 9). Thus, even when the drain is not accumulated actually, in comparison with the reference operating time T_m , $Ta2' < T_m$, whereby wrong detection occurs.

To avoid such wrong detection (to prevent the detection of the influence of the

inertia effect of the air within the tank), in the fourth operation example of Fig. 10, a pressure point P_t satisfying $P_r - P_t > \Delta P$ is set as a determining flag for determining the start of the pressure increase measurement. When the tank internal pressure lowers down to the determining flag P_t like a waveform K shown on the right in Fig. 10, a flag for checking whether the pressure can be measured or not is effective; and, when the tank internal pressure increases up to the first reference pressure P_r , the pressure measurement is started to measure a boosting time $Ta3'$ necessary for the pressure to reach the second reference pressure P_m . This boosting time $Ta3'$ is substantially equal to a boosting time $Ta3$ described in Fig. 9 when the pressure return + ΔP does not occur (or when the pressure return + ΔP is small to be neglected), thereby being able to avoid the wrong detection. The fourth operation example is similar to the third operation example of Fig. 9 in that the measured time necessary for the pressure to reach the second reference pressure P_m from the first reference pressure P_r is compared with the reference operating time T_m of the above-described memory portion to thereby detect whether a use limit quantity of drain has collected within the tank or not.

In the fourth operation example, like the waveform J shown in the central part of Fig. 10, when the pressure does not lower down to the pressure point P_t (third reference pressure) serving as the determining flag, the pressure measurement is not made.

The fourth operation example of Fig. 10 is especially effective when the consumption of the air per unit time used by a pneumatic tool is large and thus the influence of the pressure return + ΔP caused by the inertia effect of the air is great. Here, when the consumption of the air per unit time used by the pneumatic tool is small and thus the influence of the pressure return + ΔP caused by the inertia effect of

the air can be neglected, obviously, the third operation example of Fig. 9 may also be used.

Fig. 11 shows another embodiment of the invention, in which a pair of cylindrical tank bodies 5A and 5B of an air tank 5 are connected to each other by a connecting pipe 55, and the tank bodies 5A and 5B are provided with pressure sensors 11 respectively. This embodiment is similar to the embodiment of Fig. 1 in other portions thereof.

In this case, when pneumatic tools 15a and 15b connected to the tank body 5A consume the air suddenly, the pressure of the tank body 5A lowers earlier than the pressure of the tank body 5B. When the consumption of the air by the pneumatic tools 15a and 15b is stopped, the pressure of the tank body 5A increases suddenly until it becomes equivalent to (balances with) the pressure of the tank body 5B. Therefore, a state where the pressure values of the pressure sensors 11 of the tank bodies 5A and 5B are equal (a state of no pressure difference) is determined as a state where the influence of the pressure return + ΔP caused by the inertia effect of the air within the tank is gone; and, under the condition that the pressure values of the pressure sensors 11 of the tank bodies 5A and 5B are equal, by checking the measured data expressing the operating time T_a required for the pressure to reach the second reference pressure P_m from the first reference pressure P_r , there can be avoided the wrong operation that is caused by the pressure return + ΔP due to the inertia effect of the air within the tank. For example, this embodiment can be applied to the above-described first to third operation examples.

Although the invention has been described heretofore with reference to the above embodiment, it is obvious to persons skilled in the art that the composing elements and handling processes of the embodiments can be changed variously without

departing from the scope of the claims. Now, description will be given of some modifications of the invention.

In the above embodiment, the reference operating time T_m included in the reference data of the compression portion 4 (or drive portion 3) necessary to increase the pressure from the first reference pressure P_r to the second reference pressure P_m in Figs. 6 and 8 may also be a total operating time. Also, the second reference pressure is not always limited to the allowable highest pressure but may also be set for a reference pressure higher than the first reference pressure and lower than the allowable highest pressure.

Also, as described above, since the tank internal pressure increasing speed reduces as the tank internal pressure increases, the control portion may also make a determination using reference data different from each other according to timings for determining the need for notification.

Also, in Fig. 10, instead of setting the pressure point P_t serving as the determining flag, the pressure may not be measured for a predetermined time (specified time) while the tank internal pressure is increasing suddenly due to the influence of the pressure return $+\Delta P$ caused by the inertia effect of the air within the tank, but the pressure of the compressed air within the tank at the time after passage of the predetermined time from the start of the operation (the time when the pressure increases) may be set for the first reference pressure P_r , and the boosting time T_a necessary for the pressure to reach the second reference pressure P_m from the first reference pressure P_r may be measured. Or, the pressure increase rate may be measured after passage of a predetermined time from the operation start (boosting start time).

This application claims the benefit of Japanese Patent Application No.

2013-071802 filed on March 29, 2013, and Japanese Patent Application No. 2014-057489 filed on March 20, 2014, the disclosures of which are incorporated herein in their entirety by reference.

Industrial Applicability

As described above, an air compressor according to the invention has advantages of detecting and notifying that a use limit quantity of drain has accumulated in a tank with a simple and inexpensive structure. The invention is useful for the air compressor, for example.

Reference Signs List

- 1: air compressor
- 3: drive portion
- 4: compression portion
- 5: air tank
- 6: pipe
- 7: pressure reducing valve
- 8: air socket
- 9: control portion
- 9a: notifying portion
- 11: pressure sensor
- 12: drain cock
- 13: pressure gauge

CLAIMS

[Claim 1]

An air compressor comprising:

a compression portion configured to generate compressed air;

a drive portion configured to drive the compression portion;

a tank for storing the compressed air;

a pressure sensor configured to detect a pressure of the compressed air stored in the tank;

a control portion configured to store reference data expressing the relationship between the pressure of compressed air in the tank and an operating time of the drive portion and to receive pressure information from the pressure sensor; and

a notifying portion controlled by the control portion for outputting a notifying signal,

wherein the control portion is configured to:

compare measured data of the pressure information from the pressure sensor and the operating time information of the drive portion with the reference data; and

operate the notifying portion to output the notifying signal in a case where it is determined that quantity of drain accumulated in the tank has reached a predetermined value.

[Claim 2]

The air compressor according to claim 1,

wherein the control portion is configured to, in a case where an operating time taken to increase the pressure of compressed air in the tank from a first reference pressure to a second reference pressure in the measured data is equal to or shorter than

an operating time necessary to increase the pressure of the compressed air in the tank from the first reference pressure to the second reference pressure in the reference data, determine that the quantity of drain accumulated in the tank has reached the predetermined value.

[Claim 3]

The air compressor according to claim 2,

wherein a point of pressure lower than the first reference pressure is set as a third reference pressure, and

wherein the control portion is configured to, when the pressure of the compressed air within the tank lowers down to or below the pressure point and the pressure is increased, measure an operating time necessary for the pressure of the compressed air within the tank to increase from the first reference pressure up to the second reference pressure.

[Claim 4]

The air compressor according to claim 3,

wherein the third reference pressure is used as a determining flag for determining the start of the measurement of the pressure increase.

[Claim 5]

The air compressor according to claim 2,

wherein the first reference pressure is set for the pressure of the compressed air within the tank at the time after passage of a predetermined time from the pressure increase start point.

[Claim 6]

The air compressor according to claim 1,

wherein the control portion is configured to, in a case where pressure increase

quantity of the compressed air in the tank from the predetermined reference pressure with respect to a predetermined operating time in the measured data is equal to or larger than pressure increase quantity of the compressed air in the tank from the predetermined reference pressure with respect to the predetermined operating time in the reference data, determine that the quantity of drain accumulated in the tank has reached the predetermined value.

[Claim 7]

The air compressor according to claim 1,

wherein the control portion is configured to, when a pressure increase rate of the compressed air in the tank in a predetermined time period in the measured data is equal to or higher than a pressure increase rate of compressed air in the tank in the predetermined time period in the reference data, determine that the quantity of drain accumulated in the tank has reached the predetermined value.

[Claim 8]

The air compressor according to any one of claims 1 to 7,

wherein the predetermined value of the drain accumulation quantity is set for the use limit value of the drain accumulation quantity.

[Claim 9]

An air compressor comprising:

a compression portion configured to generate compressed air;

a drive portion configured to drive the compression portion;

a tank for storing the compressed air;

a pressure sensor configured to detect a pressure of the compressed air stored in the tank;

a control portion configured to store reference data expressing a relationship

between the pressure of compressed air in the tank and an operating time of the drive portion and to receive pressure information from the pressure sensor; and

a notifying portion controlled by the control portion for outputting a notifying signal,

wherein the control portion is configured to operate the notifying portion in a case where a pressure increase rate of the compressed air in the tank in measured data is equal to or higher than a pressure increase rate of the compressed air in the tank in the reference data.

[Claim 10]

The air compressor according to claim 9,

wherein the measurement of the pressure increase rate is made after passage of a predetermined time from the pressure increase start point.

[Claim 11]

The air compressor according to any one of claims 1 to 10,

wherein the notifying portion is configured to output a first notifying signal and a second notifying signal that is different from the first notifying signal.

[Claim 12]

The air compressor according to any one of claims 1 to 11,

wherein the control portion is configured to make a determination using the reference data that differs according to the measured value of the pressure sensor when determining the drain accumulation quantity.

[Claim 13]

The air compressor according to any one of claims 1 to 12,

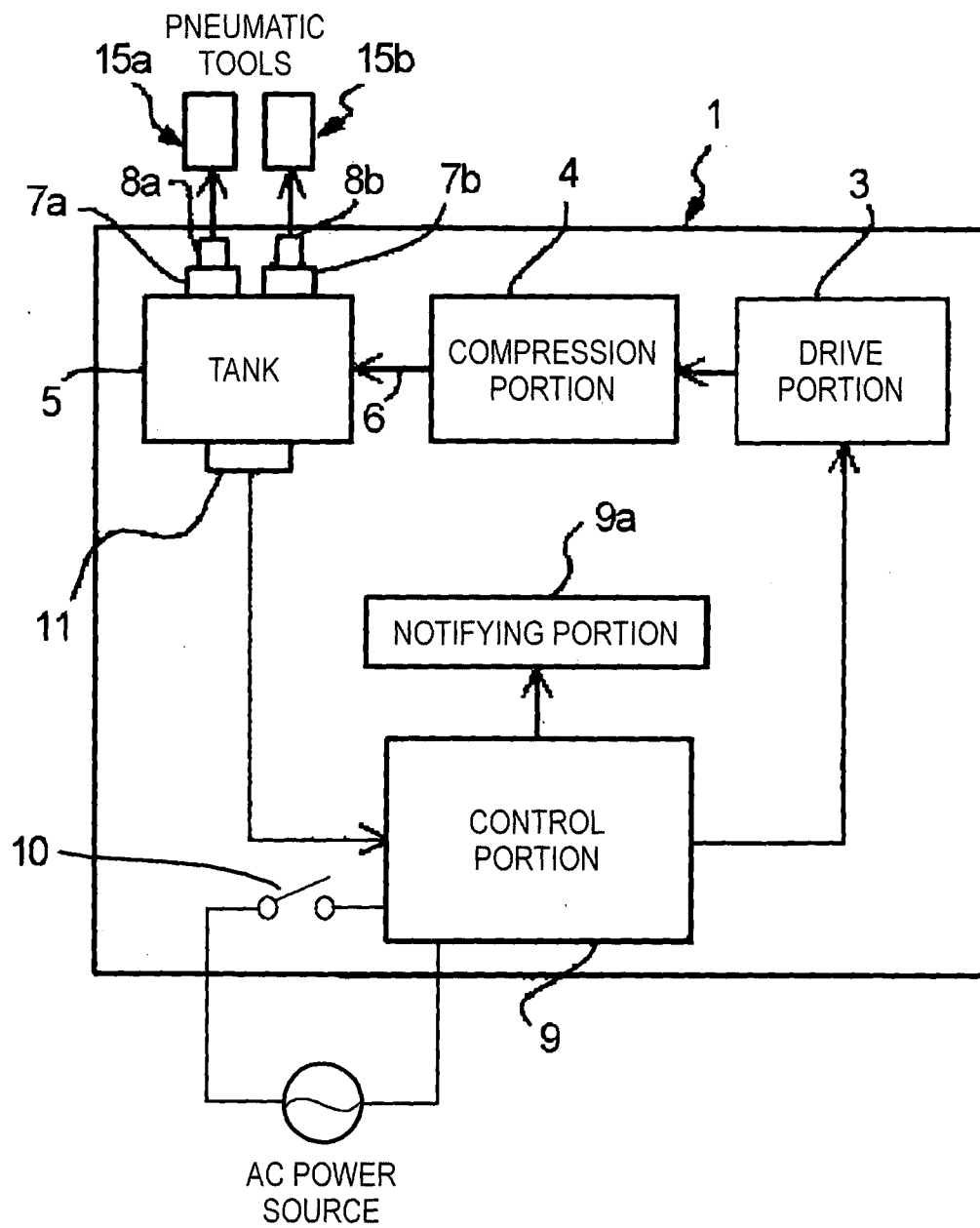
wherein the tank is configured by multiple tank bodies connected together by a connecting pipe,

wherein the tank bodies include the pressure sensor respectively, and

wherein the control unit is configured to use pressure information obtained when there is no pressure difference between the respective tank bodies.

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FIG. 1



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FIG. 2

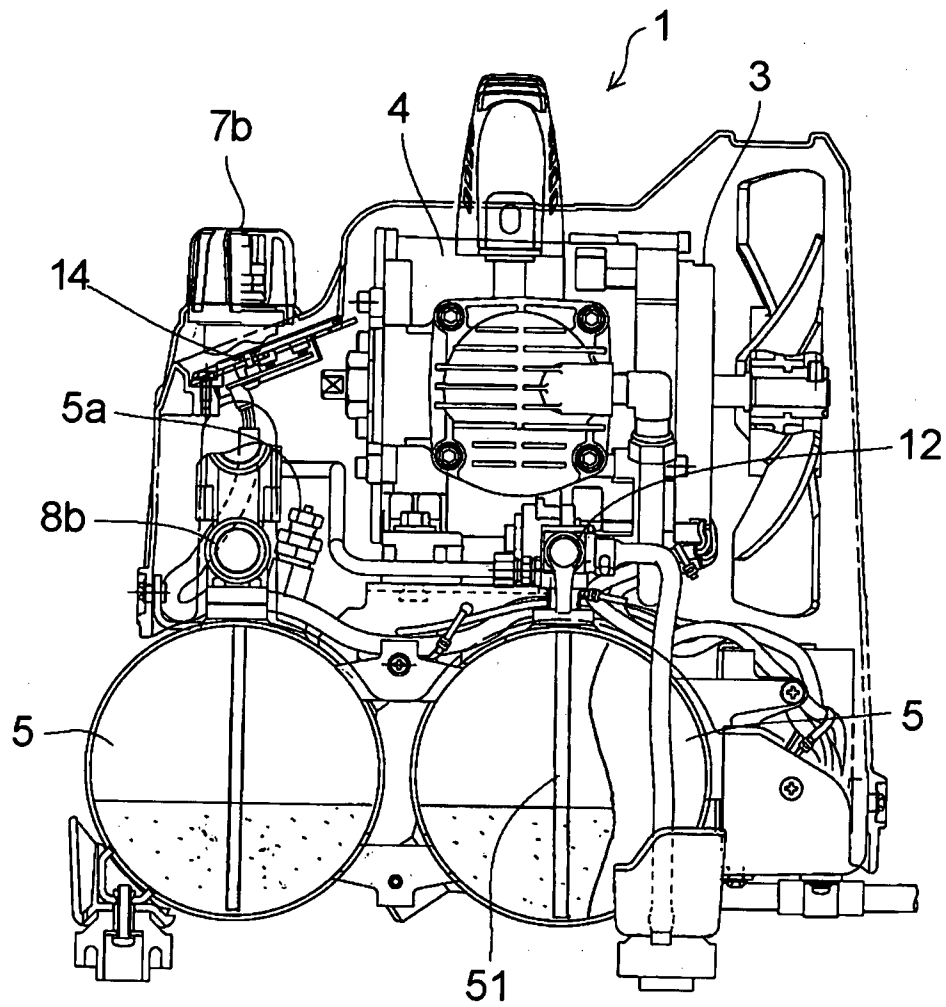
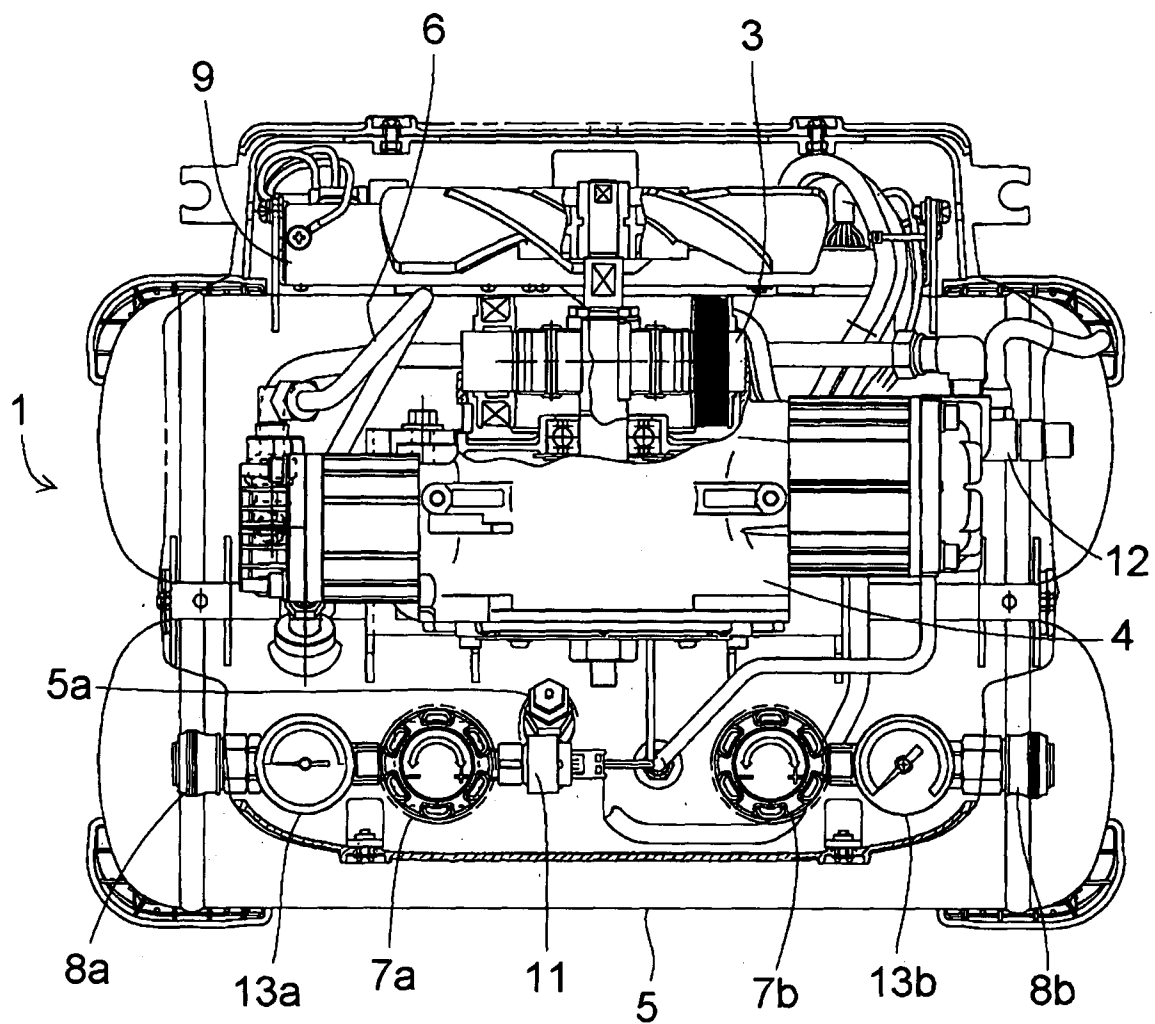


FIG. 3



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FIG. 4

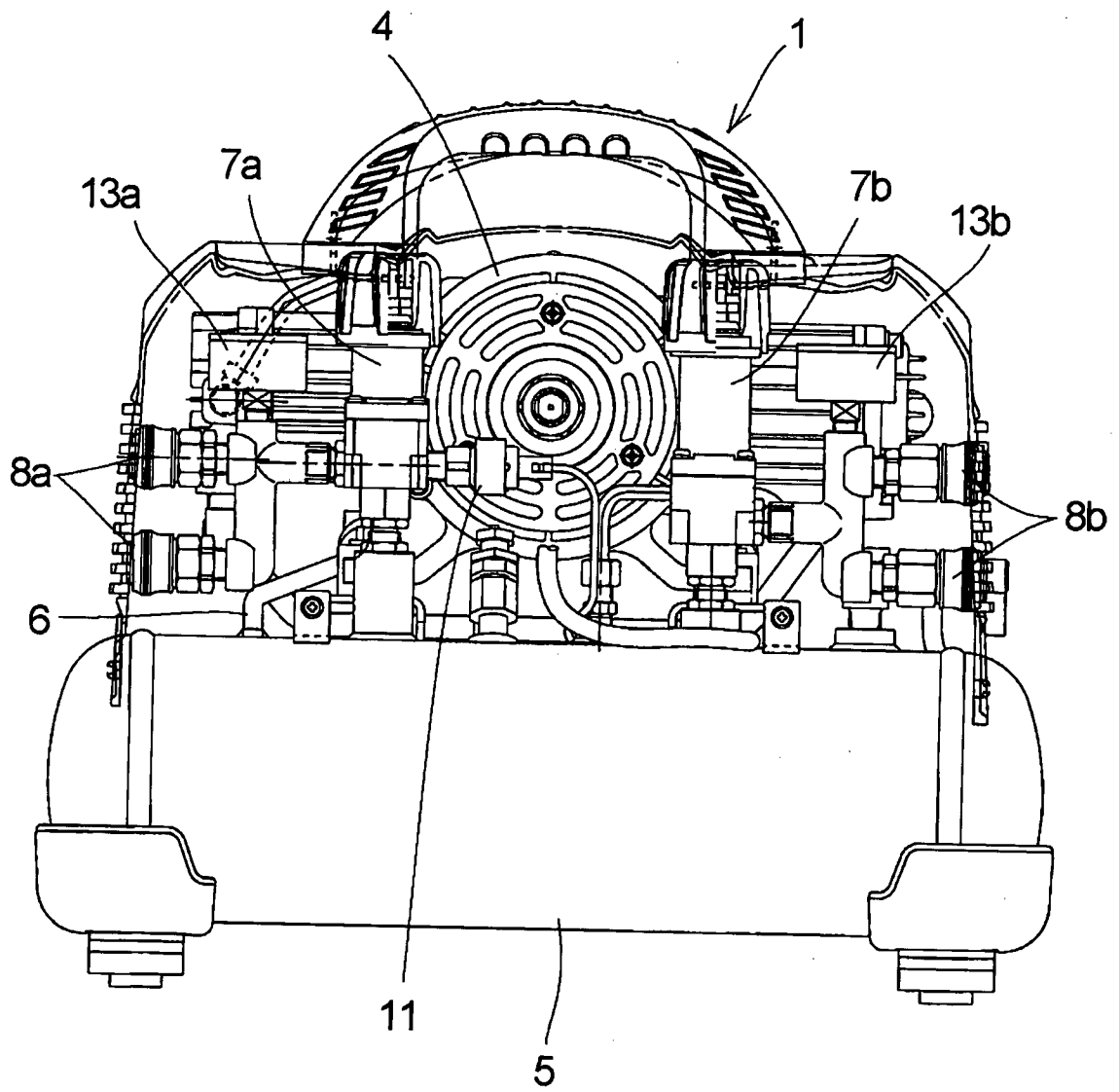
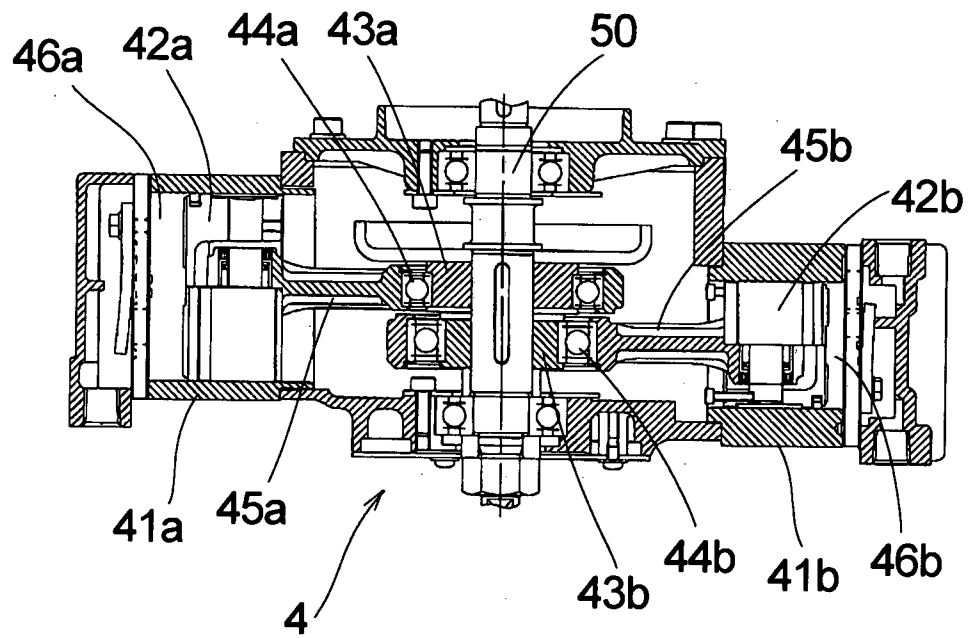
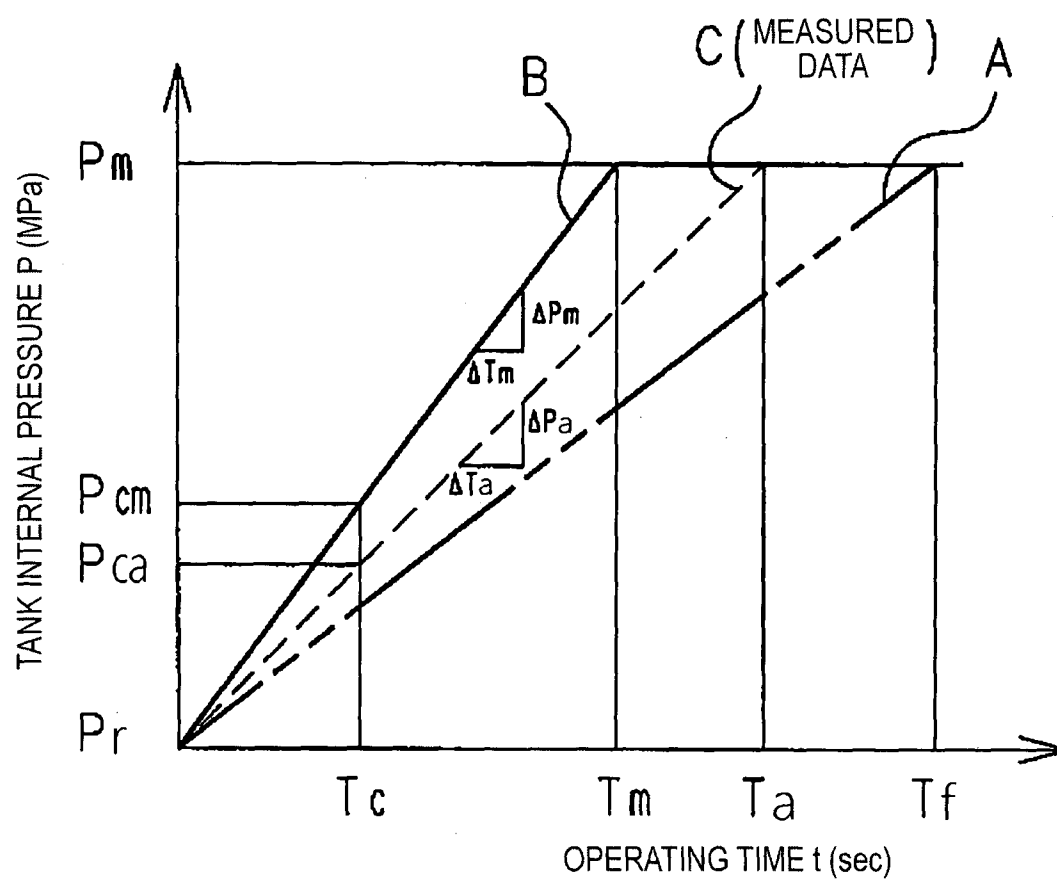


FIG. 5



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FIG. 6



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FIG. 7

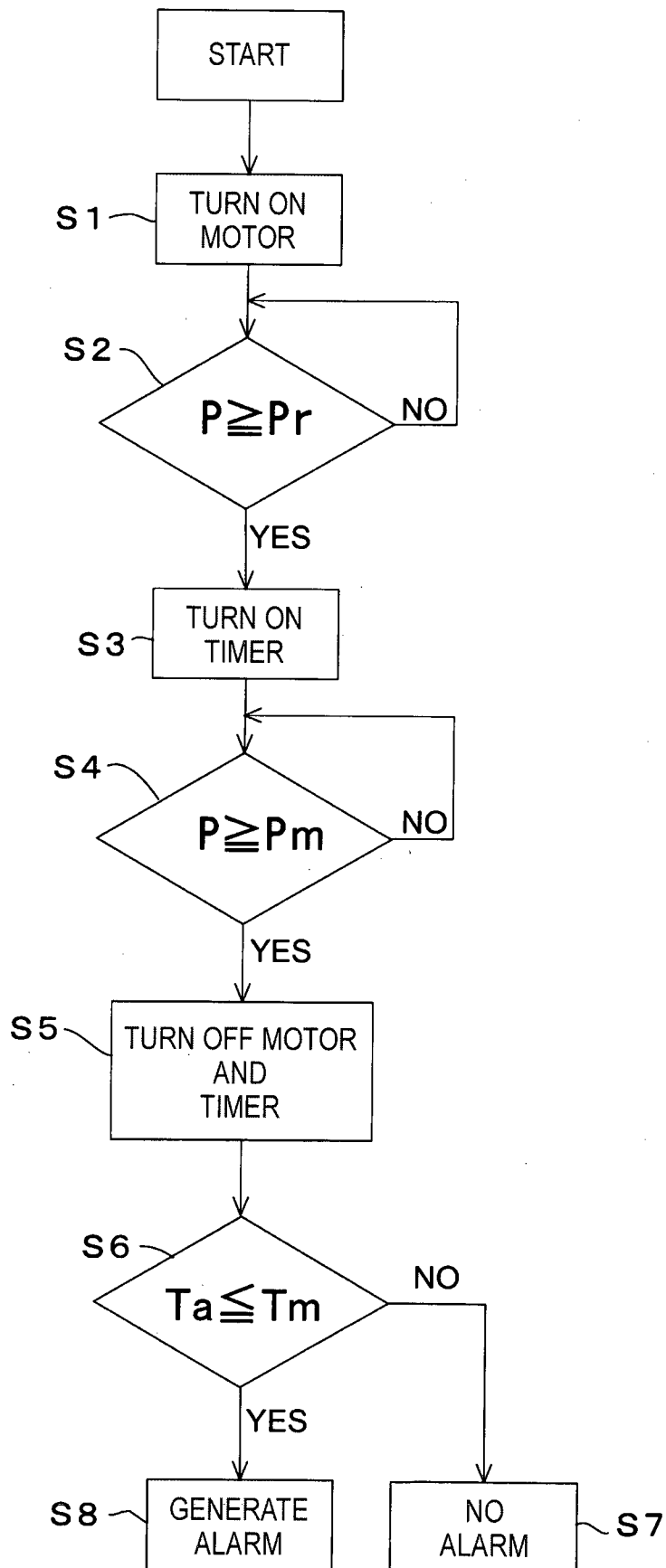
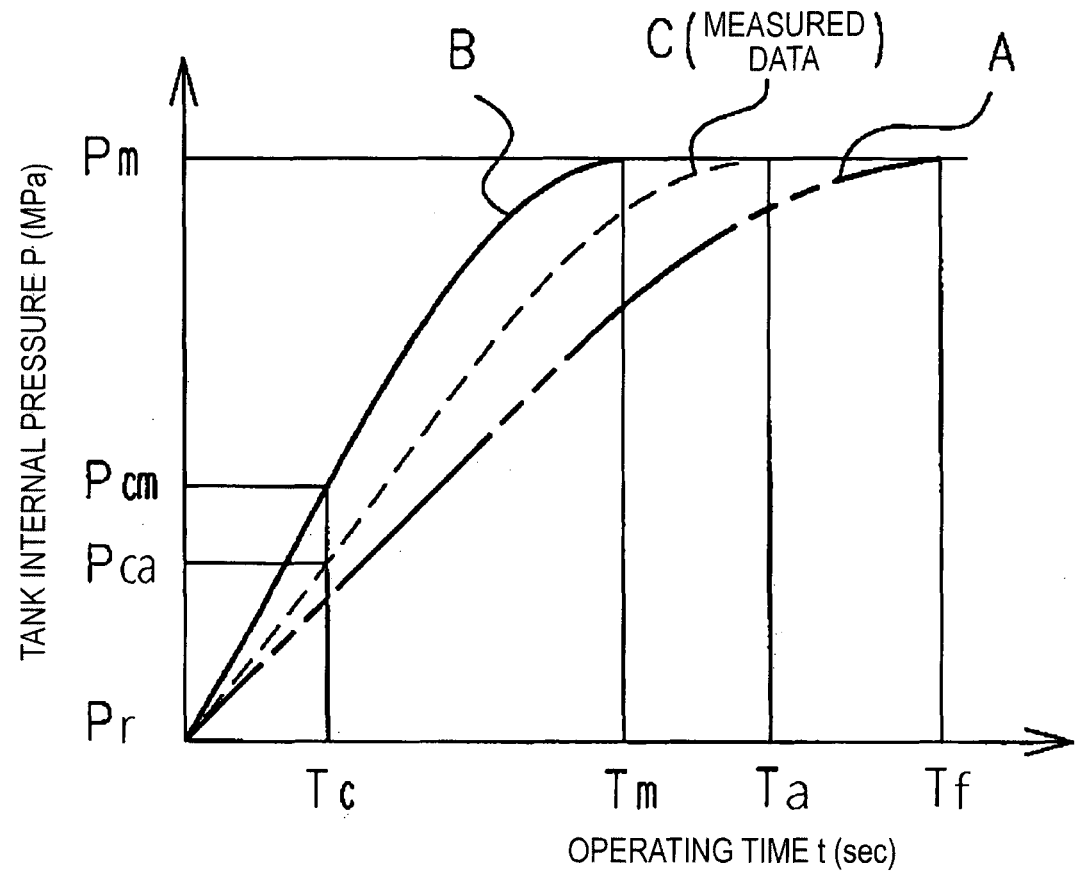


FIG. 8



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FIG. 9

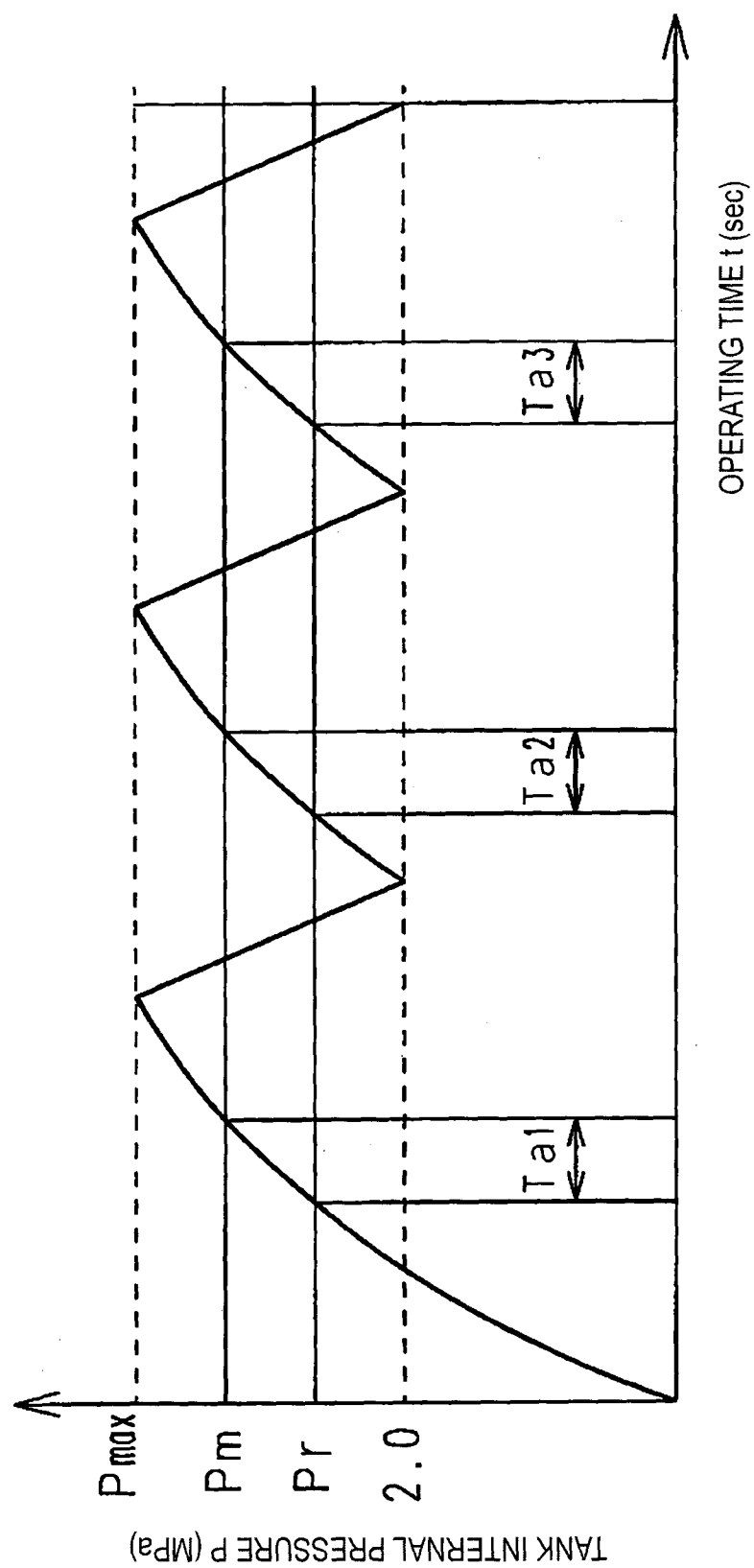
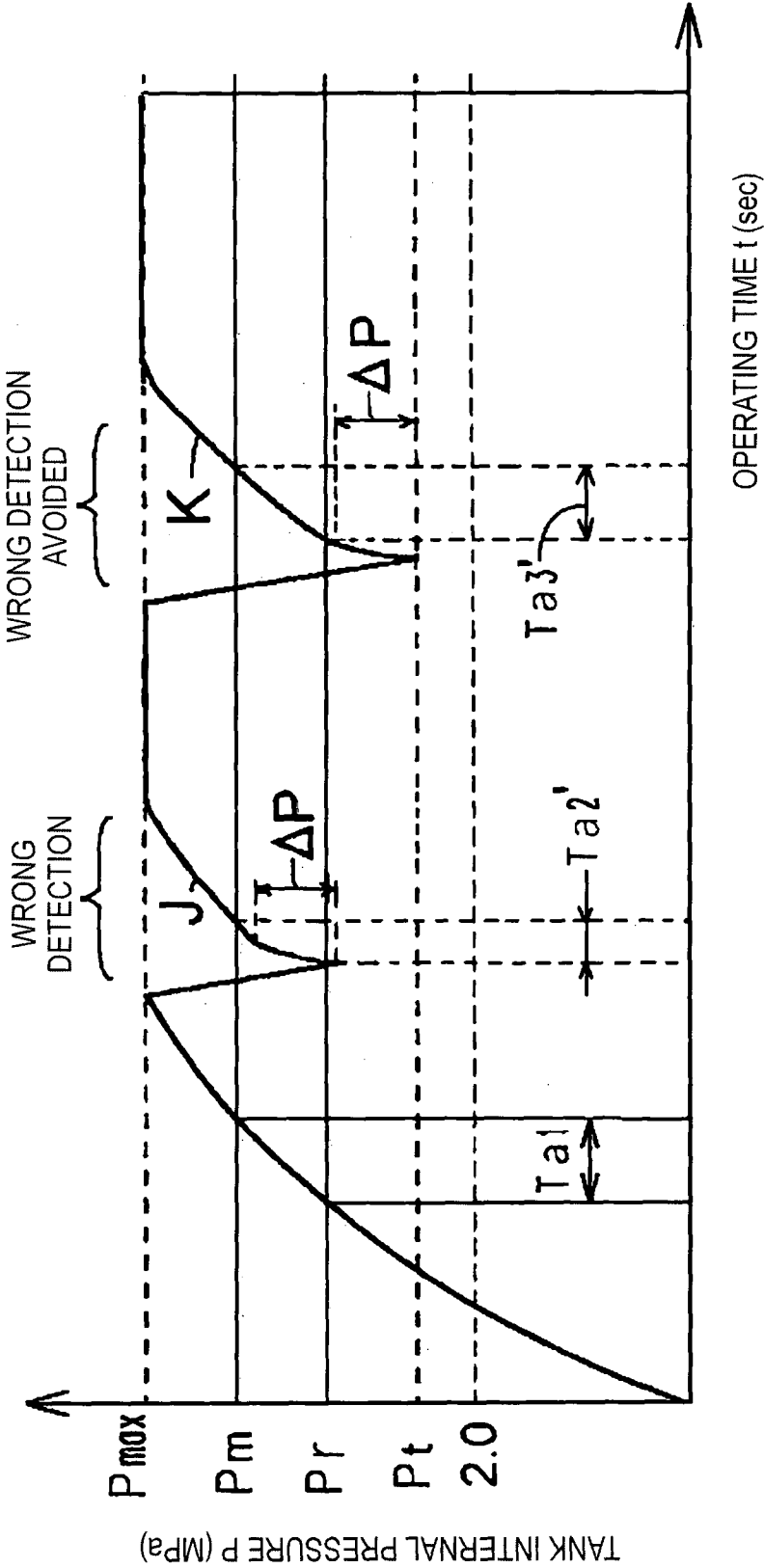
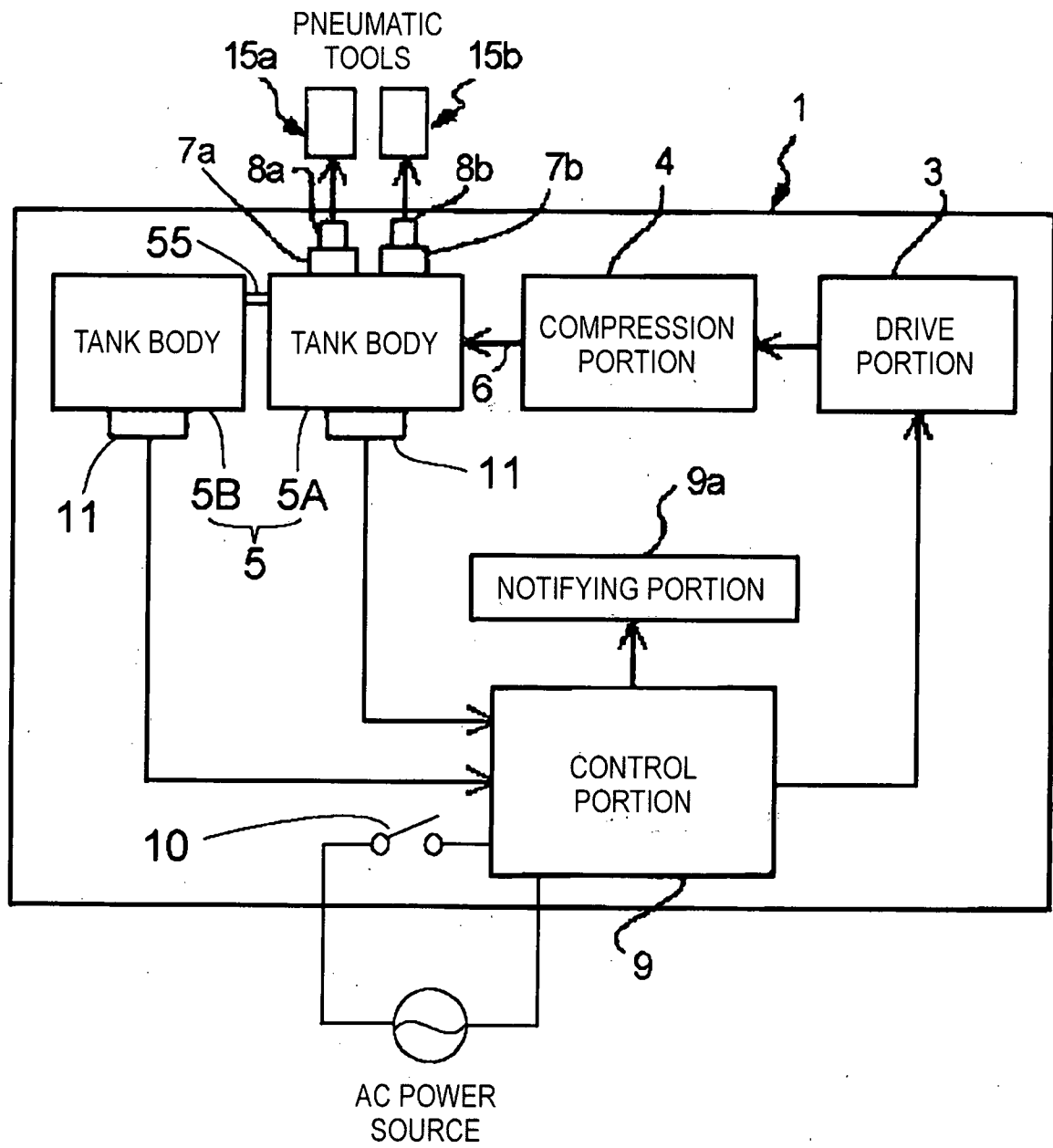


FIG. 10



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FIG. 11



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2014/059909

A. CLASSIFICATION OF SUBJECT MATTER INV. F04B41/02 F04B35/06 F04B49/06 F04B51/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F04B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4 009949 B (HITACHI KOKI KK) 21 November 2007 (2007-11-21) cited in the application the whole document -----	1-13
A	US 2013/042605 A1 (KITAGAWA HIROKI [JP] ET AL) 21 February 2013 (2013-02-21) paragraph [0018]; figure 3 -----	1-13
A	DE 10 2009 052510 A1 (KUEBRICH INGENIEURGMBH & CO KG [DE]) 12 May 2011 (2011-05-12) the whole document -----	1-13
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 16 June 2014	Date of mailing of the international search report 08/07/2014	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Olona Laglera, C	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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