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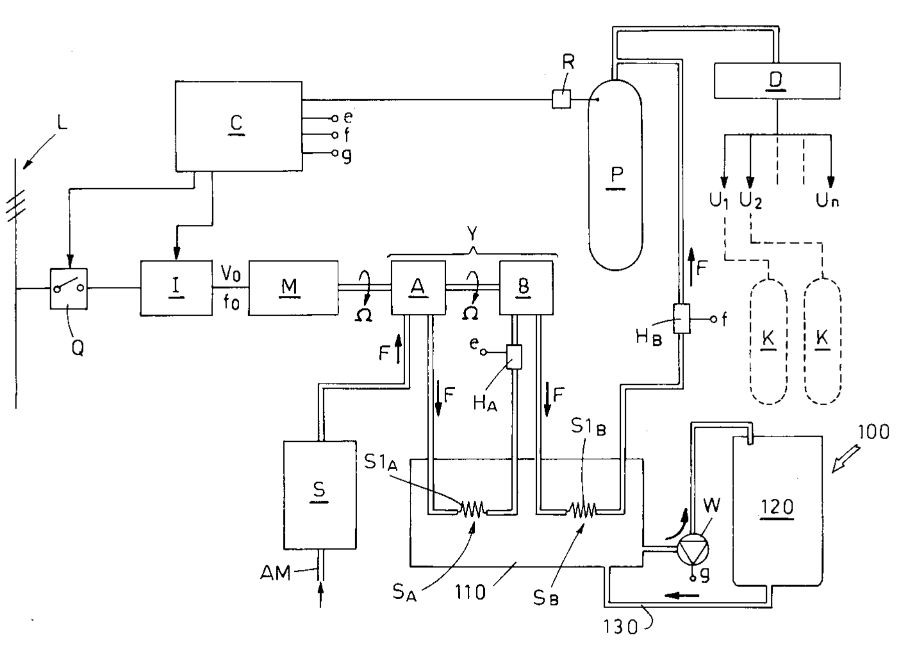
(54) **Station for supplying pressurized gas to tanks, in particular tanks installed on vehicles**

(57) Station for supplying pressurized gas to tanks, in particular to tanks installed on vehicles, includes an electric unit (1), fed by an electric main (L) and aimed at supplying at the outlet, in accordance with the control and command signals of a command and control unit (C), to which it is connected, an electric voltage of adjustable effective value (V_0) and frequency (f_0). An electric motor (M) is powered by the electric unit. A compression unit (Y) is operated by the shaft of the motor (M), and its aspiration is connected to a low pressure gas main (AM). A reference tank (P) is connected to the delivery of the compression unit (Y). A device (D) for delivering the pressurized gas is connected to the reference tank (P), and it has connectors (U1, U2, ..., Un), which can be connected to as many users (K). At least one sensor (R) for measuring pressure inside said tank (P) is connected to the command and control unit (C), which compares a selected pressure value with the pressure value measured by the sensor, and commands the electric unit (I) in relation to the pressure difference between the selected and measured values, with a consequent activation of the compression unit (Y), in which the working cycles in time unit depend on the effective value (V_0) and frequency (f_0) of the motor (M) power voltage.



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Description

[0001] There are known stations for supplying pressurized methane to the tanks of users of such stations, for example tanks installed on motor-vehicles.

[0002] These stations include substantially an electric motor (usually an asynchronous motor with a squirrel-cage rotor), aimed at operating a compressor unit (a multistage one), fed by the methane delivery main (for example with interposition of an expansion tank) feeding the gas at a pressure of about 8 - 10 bar, and for supplying, in turn, a battery of tanks connected in parallel, with a pressure, which is usually about 250 bar.

[0003] As it is known, during the compression, the temperature of methane increases, therefore it is necessary to place heat exchangers between one stage of the compression unit and another, and between the last stage and the tanks.

[0004] Known stations use gas/air exchangers, in particular consisting of a fan, which sends a jet of air, in counter-flow, on a serpentine, through which methane is made to pass.

[0005] The motor - compression unit group is activated when the delivery pressure of methane, at the outlet corresponding to the tanks (that is the user side), is lower than a prefixed value (for example 220 bar) and it is deactivated, when a selected value (for example 250 bar) is reached.

[0006] The group is activated again as soon as the pressure is lower than the above mentioned selected value.

[0007] Consequently, the above group is subjected to an "on/off" regulation, which results in many drawbacks.

[0008] When activated, the electric motor works to deliver its maximum power, therefore the corresponding electric station, supplying it, must be designed with a corresponding capacity.

[0009] As it is known, an asynchronous motor delivers a rather limited torque at the pickup moment, thus it is necessary to take measures against loading the motor shaft with an excessive resisting torque.

[0010] What above makes the aforementioned group reach its full capacity with a certain delay, with all consequent problems; in other words, the above mentioned group meets the delivery requests with a delay.

[0011] This aspect is partially compensated by the receiver effect of the battery of tanks, however all this results in an increase of time necessary to fill the users' tanks (bottles).

[0012] In order to reduce this negative aspect, in some known stations, the battery of tanks is divided in two parts, respectively at medium pressure (between 170 and 220 bar) and high capacity, and at high pressure (between 220 and 250 bar) and capacity reduced with respect to the first one.

[0013] The presence of at least one battery of tanks in the station forces the constructor to place the group and the battery inside a kind of close parallelepiped structure, having apertures for the flow of air generated by the cooling fans of the radiators, through which methane passes.

[0014] The conformation of this structure depends on the number of tanks, to comply with the relative safety requirements.

[0015] Another drawback derives from the current transients (surge current), occurring to the asynchronous motor during the pickup, partially limited by the well known star-delta starter.

[0016] A further drawback lies in the fact that in known stations, the temperature of the methane at the outlet of the last compression stage, which, in a station intended for one or more users, practically coincides with the temperature of methane delivered to the users' bottles, depends on the external air temperature; in hot months the temperature of methane introduced into the bottles can be excessive (for example 35°C), which reduces the degree of bottles filling.

[0017] The object of the present invention is to propose a station for supplying tanks with gas, in particular methane, which avoids the above mentioned drawbacks, due to its conformation allowing to modulate the delivery of gas in accordance with the users' needs.

[0018] Another object of the present invention is to propose a group electric motor - compression unit, which fits itself rapidly to the users' needs.

[0019] A further object of the present invention is to propose a station, in which the electric motor - compression unit group does not provoke surge currents during the pickup and which allows adjustments of the driving torque output by the motor shaft in accordance with the resisting torque generated by the compressor unit.

[0020] A still further object of the present invention is to propose a station, which does not need the receiver or bank effect.

[0021] Yet a further object of the present invention is to propose a station, in which the temperature of the methane introduced into the users' bottles can be adjusted and selected, so as to optimize filling of the latter independently from the climatic conditions and from the number of bottles fed contemporarily.

[0022] Another object of the present invention is to propose a station, which does not need the presence of a battery of tanks.

[0023] The above mentioned objects are obtained by the present invention, in accordance with the contents of the claims.

[0024] The characteristic features of the invention are pointed out in the following, with particular reference to the drawing, in which:

- Fig. 1 shows a block diagram of the station proposed by the invention.

[0025] The diagram does not indicate, even schematically, means and/or devices related to the systems of control and safety of the station, as they are not connected to the invention.

[0026] With reference to the figure, the reference letter L indicates an electric main (preferably three-phase), which feeds, in accordance with the condition of a switch Q, operated by a command and control unit C, a group I (known to those skilled in the art as inverter), aimed at supplying at the outlet a sinusoid voltage (in this case a three-phase tern), whose effective value V_0 and frequency f_0 vary continuously.

[0027] The group I is controlled by the command and control unit C.

[0028] The group I feeds an electric motor M, for example an asynchronous three-phase induction motor (preferably with squirrel-cage rotor), which drives into rotation a multistage compression unit Y with angular speed Ω; according to the shown example two stages A, B are considered, for example including two alternative compressors.

[0029] The aspiration of the first stage A is connected to the methane delivery main AM, in particular to an expansion tank S.

[0030] The delivery of the first stage A is connected to the aspiration of the second stage B; a first heat exchanger gas/liquid S_A is interposed therebetween. The temperature T_B1 of the flow of methane exiting the heat exchanger is measured by a sensor H_A connected to the command and control unit C.

[0031] The cooling liquid of the first heat exchanger S_A, preferably water, circulates in a circuit 100, which includes: a chamber 110 with the serpentine $S1_A$ of the exchanger S_A, in which the gas passing through the serpentine is cooled; a liquid/air heat exchanger 120, for example a cooling tower (known also as evaporation tower), which receives the liquid from the chamber 100 by means of a pump W controlled by the command and control unit C; a channel 130 connecting the liquid/air heat exchanger 120 with the chamber 110, allowing the liquid, cooled in the exchanger, to return to the chamber 110.

[0032] The delivery of the second stage B is connected to a reference tank P and a second gas/liquid heat exchanger S_B is interposed therebetween. The temperature T_f of the methane at the delivery of the second stage B is measured by a sensor H_B connected to the command and control unit C.

[0033] In the shown example, the serpentine $S1_B$ of the second exchanger S_B is connected to said cooling circuit 100; for this purpose it is situated inside the chamber 110.

[0034] It is understood that the serpentines $S1_A$, $S1_B$ of the gas/liquid heat exchangers S_A, S_B, first and second, can be connected to corresponding circuits, independent one from another, so as to cool the liquid circulating in the circuits, for example, by means of gas/liquid heat exchangers of the type described with reference to the circuit 100.

[0035] The pressure of methane inside the tank P is measured by a sensor R connected to the command and control unit C.

[0036] The tank feeds a supplying device D, having attachments of known type, indicated with U1, U2, ...Un, which allow the connection with the bottles of a corresponding number of users K.

[0037] It is known that the mechanical characteristics of an asynchronous three-phase induction motor are function of the effective value V_0 and of the frequency f_0 of the supplying voltage; consequently, it is possible to change the torque and the angular speed Ω of the motor shaft by continuous adjusting the above mentioned parameters.

[0038] Accordingly, it is possible to change the number of revolutions in time unit (rpm) of the motor shaft, and obviously, of the number of working cycles in time unit of the compression unit Y.

[0039] It is to be pointed out that, the temperature T_B1 of the methane at the inlet of the second stage B (measured by the sensor H_A) can be adjusted to the desired value by changing the speed of the pump W disposed in the cooling circuit 100 of the liquid flowing through the first exchanger S_A, by means of the command and control unit C, while the other conditions remain unchanged.

[0040] Likewise, the temperature T_f of the methane sent to the tank P can be adjusted to the desired value (e.g. 25°C) by changing the speed of the pump W through the command and control unit C, while the other conditions remain unchanged.

[0041] In the example taken into consideration, there is only one liquid/air cooling circuit for both gas/liquid exchangers; however, this does not create a limitation, because the temperature to be controlled and adjusted to the desired value is the T_f temperature of the gas sent to the tank P.

[0042] The operation of the station proposed by the present invention results to be obvious from the above description.

[0043] In rest conditions, that is when the device D does not deliver any methane, the station must be ready to operate, that is, it must be able to serve the users.

[0044] For this purpose, the reference tank P must contain methane at a selected pressure (for example: 240 - 250 bar) obtained in the way explained later on.

[0045] The selected value is stored in the command and control unit C.

[0046] The connection of at least one user tank (bottle) to the supply device D makes the tank P deliver methane immediately.

[0047] Consequently, the pressure in the tank P tends to lower, which is picked up by the sensor R.

[0048] The command and control unit C compares the selected value with the picked up value, and since the selected stored value in higher, it activates the inverter, which in turn operates the motor M.

[0049] The motor pickup occurs gradually and, at the same time, rapidly, while the value of the delivered torque has a substantially linear path with respect to the angular speed Ω.

[0050] During this pickup, there are practically no surge currents, since the motor is fed in such a way, as to avoid them.

[0051] What above causes the activation of the compressor unit Y and of the means connected thereto; in particular, the command and control unit C adjusts the speed of the pump W, so as to impose the selected value of T_f temperature of methane, sent in parallel to the tank P and to the supply device D.

[0052] The delivery of the "pumped" methane must satisfy the users K needs.

[0053] When the quantity of delivered methane increases (for example: the number of users K increases), the pressure of the delivered methane tends to decrease, which is picked up by the sensor R, and consequently by the command and control unit C.

[0054] The command and control unit C controls in a suitable way the inverter I, which increases the effective value V_0 and frequency f_0 of the voltage supplied to the motor M.

[0055] Consequently, the motor shaft increases the delivered torque and speed, which results in the increase of the number of working cycles of the compressor unit Y in the time unit.

[0056] Thus, the station sends a required quantity of methane to the supply device D.

[0057] In these conditions, the decrease of the quantity of delivered methane causes the increase of the pressure with respect to the previous situation, which is picked up by the sensor R.

[0058] The command and control unit C, by means of the inverter I, changes the electric parameters of the motor powering voltage, so as to reduce the number of working cycles of the compressor unit, to adjust the quantity of "pumped" methane in accordance to the contingent situation of required delivery.

[0059] Consequently, the proposed station "pumps" such a quantity of methane, which depends on the quantity of methane delivered by the device D, in other words, it depends on the number of users K connected to the device D.

[0060] When the last user K is disconnected from the device D, the station continues to "pump" methane to the tank P, until a pressure value equal to the prefixed one is reached inside the tank P.

[0061] In these conditions, the motor M is de-activated and the station is ready to deliver methane as soon as a user K is connected to the device D.

[0062] The compressors used during the compression stages A, B are alternative, therefore the pressure of the "pumped" methane is not continuous and have pulses with respect to the medium value.

[0063] The pulses inside the reference tank P are minimized to negligible values; consequently, the value measured by the sensor R is not subjected to the pulses.

[0064] The proposed technical solution has various technical-functional advantages.

[0065] The motor startup does not cause surge currents, which is positive for the motor itself, as well as for all the means situated upstream of the inverter.

[0066] The motor is started rapidly and under loaded condition, which is positive for the compliance (elasticity) of the station to the effective methane request.

[0067] The motor M - compression unit Y group must satisfy the maximum load conditions, that is with all the attachments U1, ..., Un connected to a corresponding number of users; in other conditions, the group exploits only a part of its capacity.

[0068] The proposed station adapts rapidly to the increases or decreases of the methane request; in these conditions the motor - compression unit group is activated, so as to "auto-adapt" to the changing delivery requests.

[0069] The motor - compression unit group is deactivated, when the pressure in the tank P is equal to the selected value; this occurs when the device D stops delivering methane.

[0070] It is to be pointed out that the reference tank P has a limited capacity, because its function is to allow the determination of a reference pressure, which is extremely positive for the station costs, as well as the dimensions of the structure containing it.

[0071] The station, proposed by the invention, allows an adjustment of the methane temperature Tf to a value, which optimizes the users' bottles filling.

[0072] It is to be pointed out that the proposed station has only one circuit 100 for cooling the liquid of both gas/liquid exchangers S_A, S_B; which results in the simplification of the station construction, with consequent costs reduction, as well as of the station maintenance.

[0073] Another advantage of the invention derives from the fact that it uses a particular heat liquid/air exchanger to cool the liquid of the cooling circuit 100, more precisely, an evaporation tower.

[0074] Thus, the production of the circuit 100 is simplified, and the control of the speed of only one pump W allows adjustment of the temperature Tf of the methane "pumped" to the delivery device D.

[0075] The shown example takes into consideration two compression stages; it is understood that the proposed technical solution does not depend on the number of stages.

Claims

1. Station for supplying pressurized gas to tanks, in particular to tanks installed on vehicles, **characterized in that** it includes:

   - an electric unit (1), fed by an electric main (L) and aimed at supplying at the outlet an electric voltage of variable effective value (V_0) and frequency (f_0), in accordance with control and command signals issued by a command and control unit (C), to which it is connected;

- an electric motor (M) powered by said electric unit;

- a compressor unit (Y), which is operated by the shaft of said motor (M), and whose aspiration is connected to a low pressure gas main (AM) feeding said gas;

- a reference tank (P), connected to the delivery of said compression unit (Y);

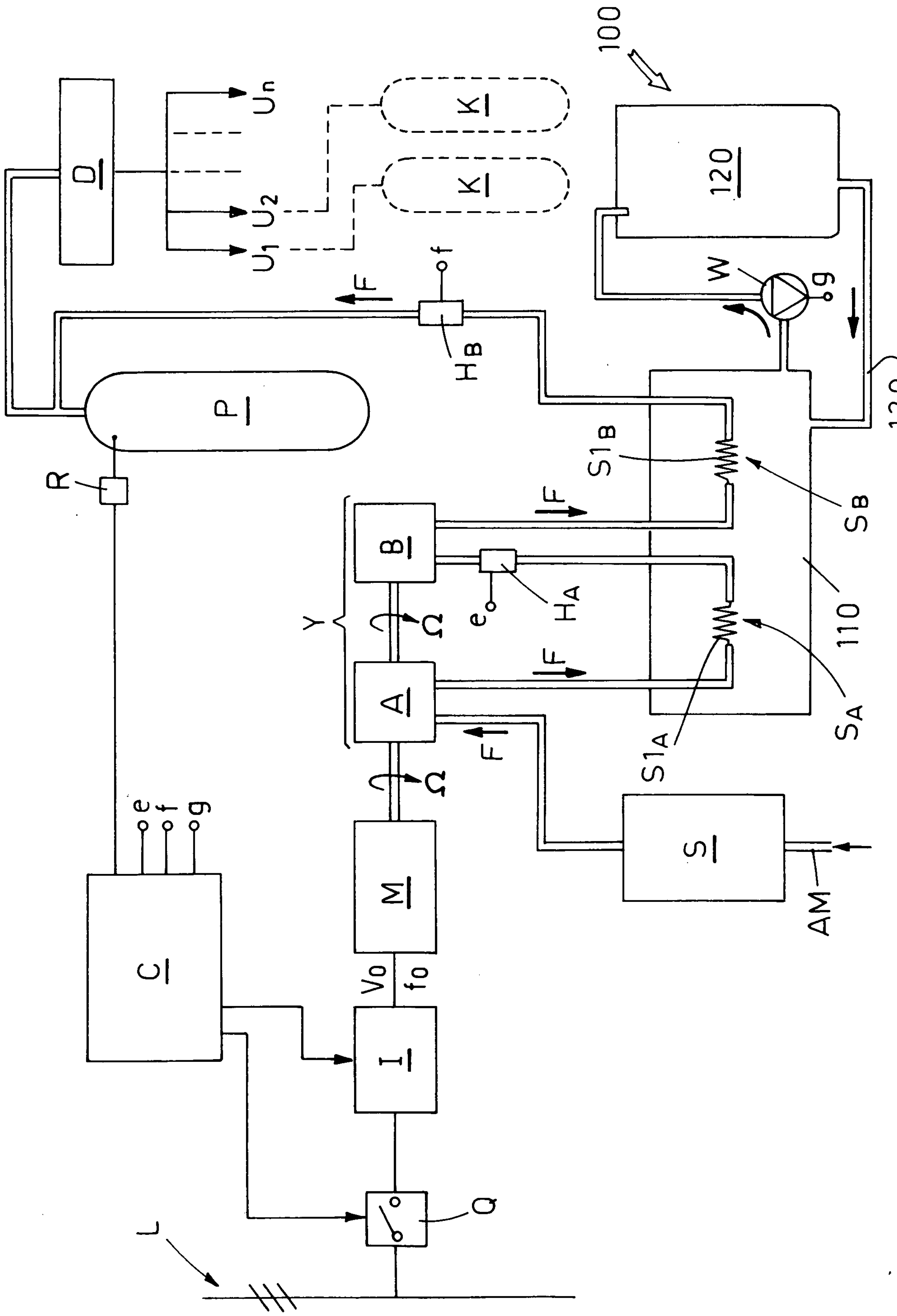
- a device (D) for delivering said gas under pressure, connected to said reference tank (P), and having connectors (U1, U2, ..., Un), which can be connected to a corresponding number of users (K);

- at least one sensor (R) for measuring pressure inside said reference tank (P), the sensor being connected to said command and control unit (C), which compares a selected pressure value with the pressure value measured by the sensor, and controls said electric unit (I) in relation to the pressure difference between said selected and measured values, with a consequent activation of said compression unit (Y), in which the working cycles in time unit depend on said effective value (V_0) and said frequency (f_0) of said motor (M) power voltage.

2. Station according to claim 1, **characterized in that** said compressor unit is defined by at least one compression stage (A,B), whose delivery is connected to said reference tank (P), with at least one heat exchanger disposed therebetween for cooling said gas, in which said exchanger ($S1_A$, $S1_B$) is a gas/liquid exchanger, and the liquid, in turn, is cooled by a liquid/air heat exchanger (120).

3. Station according to claim 2, **characterized in that** the circuit (100), containing said cooling liquid, includes at least one pump (W) and at leas one sensor (H_A, H_B), which measures the gas temperature at the delivery of said compression stage, said sensor being connected to said command and control unit (C), which controls said pump (W), in relation to the difference between a selected temperature value and the value measured by said sensor (H_A, H_B), with consequent maintaining of the gas temperature (Tf) at the above mentioned selected value.

4. Station, according to claim 2, **characterized in that** said liquid/air heat exchanger (120) is a cooling tower.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