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(54) **DEVICE AND METHOD FOR CONTROLLING THE RECOVERY OF THE VAPOURS IN FUEL
DISTRIBUTOR COLUMNS**

VORRICHTUNG UND VERFAHREN ZUM KONTROLLIEREN DER RÜCKGEWINNUNG VON
DÄMPFEN IN KRAFTSTOFF-ZAPFSTELLEN

DISPOSITIF ET PROCEDE SERVANT A COMMANDER LA RECUPERATION DES VAPEURS DANS
DES COLONNES DE DISTRIBUTION DE CARBURANT

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Description

[0001] The present invention relates to the columns of fuel distributors, in particular columns which are provided with a system for recovery of the vapours emitted during the operations of supply to vehicles.

[0002] In fuel distributors, and in particular in street distributors for supply to vehicles, the standards for safety and protection of the environment require that the vapour phase, which consists of a mixture of air and fuel vapours, and is discharged from the tanks of the vehicles as they are being supplied, is not dispersed into the environment.

[0003] This emission is caused substantially by the effect of displacement by the fluid admitted into the tank, which reduces the volume above its level, and expels an equivalent volume of vapour phase.

[0004] According to the known art, this air/vapour phase is sucked up by providing the fuel distributor pistols both with fuel distribution nozzles and suction nozzles, which are connected to volumetric pumps. The distributor pistol is connected to the column by piping for delivery of the liquid fuel, which is supplied by a pumping unit with a variable flow rate, as well as by suction piping which is connected to a volumetric pump for suction of the vapours, which is actuated with a flow rate which is closely correlated, moment by moment, to the fuel delivery flow rate.

[0005] According to the known art, various systems have been proposed for recovery of the vapours, i.e. of the air/ vapour phase, which is discharged from the tanks of the vehicles as they are being supplied, for example in US. 5,038,838

[0006] EP-B-461,770 WO 98/00641, WO 96/06038 and DE 4200803.

[0007] In order to clarify the technical problems which are associated with the recovery of the vapours in the columns, reference is made to the diagram in Figure 1, relating to a distributor column which is provided with a single distributor pistol.

[0008] The column 10 is provided with a box-shaped support structure 11, which contains and supports its units.

[0009] The fuel is contained in an underground tank, not shown in the Figure, from which the fuel is obtained by means of the suction line, which consists of the intake 12, the pumping unit 13, which is connected to the distributor pistol 18, and the measurer 14, which measures the quantity of fuel distributed, before conveying it via the pipe 15 to the separator 16, from which the flexible tube 17 of the distributor pistol 18 extends.

[0010] There is connected to the measurer 14 a pulse generator 20, which generates an electric pulse for each fuel unit distributed, for example for each centilitre; this pulse signal has a frequency which is proportional to the flow rate, and is transmitted to the indicator head 21, which, on the basis of the number of pulses, calculates and indicates the quantity distributed, and the corre-

sponding price of the supply.

[0011] The same signal is transmitted to the electronic control unit 22, which controls and pilots the vapour recovery system.

[0012] The tube 17 of the distributor pistol 18 contains both a fuel delivery pipe 23, which is the extension of the delivery pipe 15 as far as the distribution nozzle, and a return pipe 24, which is connected to a suction nozzle located in the vicinity of the distributor nozzle.

[0013] This nozzle sucks up the vapours which are expelled from the tank which is being filled; this return tube 24 is connected in the separator 16 to a pipe 25, which is connected to the volumetric pump 26 for suction of the vapours, which is actuated by a motor 27, which is piloted by the electronic control unit 22 at a number of revolutions, which is in relation, moment by moment, to the frequency of the pulse signal of the generator 20, such as to correlate the revolutions of the pump 26, and thus the volumetric suction flow rate, to the flow rate of delivery of the fuel.

[0014] The delivery of the volumetric pump 26 is readmitted via the pipe 28 into the underground tank of the distributor, from which the fuel is obtained; in general, the volumetric ratio between the fuel distributed and the gaseous phase which is sucked up is set and maintained with an interval of values which is close to the unit value; this setting can be varied according to the type of fuel and the environmental conditions.

[0015] The fuel is typically distributed with a variable flow rate, which is regulated by the operator by means of the pressure exerted on the lever 30 for regulation of the pistol, whereas the suction flow rate must follow moment by moment the development of the delivery flow rate.

[0016] In practice, the sequence of the pulses represents faithfully the situation, moment by moment, of the distribution of liquid which takes place, with the number of pulses corresponding to the quantity distributed, and the frequency of the pulses corresponding to the instantaneous flow rate; however, piloting of the volumetric suction pump, which takes place by modulating its instantaneous speed, i.e. its number of revolutions per minute, on the basis of the instantaneous frequency of the pulses of the measurer, is not equally accurate in the final result of obtaining a constant ratio between the volumetric flow rates of the liquid distributed, and of the vapour sucked up.

[0017] In fact, the most common types of volumetric pumps used to recover the vapours in the fuel distributors are vane pumps, roller pumps, and alternative types of pumps, and they have a characteristic flow rate/speed curve which is not at all linear, and which therefore does not make it possible to obtain a constant ratio between the flow rates of the liquid distributed and of the vapour sucked up, if operation takes place on the basis of the frequency of the pulses of the measurer/generator, when the speed of distribution is varied, and the revolutions/minute of the volumetric pump are consequently

regulated linearly.

[0018] Figures 2A and 2B show indicatively the typical developments of the characteristic curves (flow rate/speed) for these types of volumetric pumps functioning in a vapour recovery system. In particular, Figure 2A shows the development of the characteristic curve of a vane or roller pump, whereas Figure 2B illustrates qualitatively the development of a characteristic curve of an alternative pump.

[0019] In fact, these characteristic curves show the development of the pump/circuit system in conditions of constant losses of load ΔP_1 and ΔP_2 (where $\Delta P_2 > \Delta P_1$). The technical problem is further complicated in the most recently designed distribution systems in which each column is provided with a plurality of distributor pistols, each of which is connected to a different underground fuel tank, for example super leaded petrol, unleaded petrol of various qualities, diesel and so on.

[0020] In this case, in fact, for each group of pistols 18 on the same side of the column 10, only a single distributor pistol can function at once in order to supply to the vehicle which is standing in front of the column, whereas each group of pistols 18 on each side is provided with a volumetric suction pump 26. Downstream from the volumetric pump 26, in the case of most distributor pistols 18, the delivery pipes for the vapours sucked up into the corresponding underground tanks are sub-divided into various pipes 28, and on each of these there is installed a switching system which comprises a series of non-return valves, one of which is shown schematically in Figure 1, and is generally indicated as 31, downstream from the pump 26. There also exists the problem of any imbalances in the losses of load which occur in the branches of the system, as a result of the different calibrations of the valves, the different lengths of the various branches and so on, such that each branch for delivery of the vapours to the tank does not operate with the same loss of load, but according to different characteristic flow rate/speed curves, as indicated in Figures 2A and 2B. Thus, depending on the cases, the volumetric pump 26 operates on vapours with different densities, depending on the type of fuel, at different temperatures, and with different pressure values downstream.

[0021] From the foregoing information, it is apparent that operating with linear correlation between the frequency of the pulses of the generator 20 and the speed of revolution of the motor 27 of the pump 26, does not guarantee a constant ratio between the flow rates of the liquid phase distributed and the vapour phase sucked up, but rather, substantial divergences from this constant ratio occur.

[0022] The object of the present invention is thus to indicate a method for controlling the recovery of the vapours in fuel distributor columns, which take into account the actual operative conditions, and makes it possible to fulfil the requirement of establishing and maintaining a predetermined ratio in terms of volume, be-

tween the flow rates of the liquid distributed and the vapour sucked up, both when the flow rate of liquid distributed is varied, and when the fuel or the associated conditions are varied.

[0023] According to the present invention, the technical effect required is that of imparting to the vapour recovery system the capacity to obtain a ratio between the flow rates pre-determined and required, both during the phase of initial calibration and that of periodic control, simply by means of an operation of modulation of the speed of revolution of the electric motor which is connected to the volumetric pump. The method according to the present invention is defined in the following claim 1.

[0024] The method according to the invention makes it possible to obtain linear proportionality between the quantity of vapours recovered and the quantity of product distributed, by means of an electronic control unit, which controls suitably the variation of speed of the vapour suction pump; the number of revolutions of the pump varies according to the signal obtained from a pulse generator, via an electronic head.

[0025] The characteristics and advantages of the method according to the present invention will become more apparent from the following description of a typical embodiment, provided by way of non-limiting example, with reference to the attached schematic drawings, in which:

- Figure 1 is a schematic representation of a distribution column with a distributor pistol, with recovery of the vapour phase;
- Figures 2A, 2B are two Cartesian diagrams showing qualitatively the developments of the characteristic flow rate/speed curves, relating respectively to a system with a vane or roller pump, and a system with an alternative pump. In particular, Figures 1, 2A and 2B illustrate the technical problem to which the present invention relates;
- Figure 3 is a block diagram of the control device for recovery of the vapours, according to the present invention;
- Figures 4A, 4B, 4C, 4D, show a first embodiment of a wiring diagram of the vapour recovery control device according to the present invention;
- Figure 5 relates to a second embodiment of a wiring diagram of the control device, according to the present invention;
- Figure 6 shows a Cartesian diagram which illustrates the qualitative development of the ratio V/L , when the flow rate varies in a vapour recovery system which is provided with a proportional valve, with a pump with a fixed number of revolutions, which is controlled mechanically by the motor of the pumping unit, or by an independent motor;
- Figure 7 shows a Cartesian diagram which illustrates the qualitative development of the ratio V/L , when the flow rate varies in a vapour recovery sys-

tem with a pump with variable revolutions, which is controlled electronically; and

- Figure 8 shows a Cartesian diagram which illustrates the qualitative development of the curve of corrective values, when the point of operation is varied, and which can be used in the vapour recovery system in accordance with the control device according to the invention.

[0026] With particular reference to Figure 3, the same components which are already present in Figure 1 are indicated by the same references, whereas 35 indicates schematically a block relating to the actual vapour recovery system, which permits recovery of the petrol vapours which are discharged from the tank of the vehicles whilst they are being re-supplied with fuel, as already previously described in detail, and 33 indicates a connection block for the signals obtained from the pulse generator 20 and from the head 21.

[0027] The system 35 comprises the volumetric suction pump 26, which is connected to its own electric motor 27, and has a level of protection suitable for fitting in a dangerous area, and an electronic control unit 22, which is fitted in a non-dangerous area.

[0028] The volume of the vapour recovered depends on the flow rate of fuel distributed, and in order to be able to carry out this regulation, the control unit 22 detects the pulses obtained from the electronic head 21, or directly from the pulse generator 20, and acts on the speed of the motor 27 of the pump 26. The vapour recovered is conveyed into the fuel storage tank via the flexible pipe 24, which is coaxial relative to the delivery tube 23 for distribution of the fuel. The vapour recovery system 35 can be used for suction of vapours of normal, super and super unleaded petrol.

[0029] According to a preferred, but non-limiting embodiment of the present invention, the electronic unit 22 controls the speed of the brushless-type motor 27, and is supplied with monophasic alternating current, thus guaranteeing satisfactory operation for a supply voltage equivalent to 230 Volts (nominal value) and a supply voltage frequency of 50 Hz.

[0030] In practice, the electronic control unit 22 receives as input a series of reference signals, which are processed correspondingly, such as to render virtually linear the function which associates the volume of the vapour recovered by the system 35, with the volume of the fuel distributed, which function actually follows a non-linear development.

[0031] For this reason, it is necessary to introduce a compensation curve which, for some values (determined by means of prior calibration of values which can be set on an actual suction pump 26) of a speed reference signal transmitted to the intake of the control unit 22, determines an actual speed of the suction pump 26; the speed reference input of the unit 22 is piloted by a square-wave signal with a frequency of between 0 and 200 Hz, which is normally supplied by the electronic

head 21, via the pulse generator 20. The control unit 22 has a regulator, such that it can adapt to the different amplitudes (typically +5V to +12V, or +12V to +35V) of the signal obtained from the pulse generator 20, such that it can interface with the pulse generators which are currently most commonly available on the market, the output stage of which can be of the NPN open collector, PNP open collector, totem-pole, or push-pull type.

[0032] The speed coefficients of the compensation curve are obtained by means of a device which makes it possible to determine these values automatically at the various distribution flow rates; alternatively, these coefficients can be calculated by means of an applicative programme which is installed on an electronic processor, which makes it possible to store up to 100 coefficients in a frequency interval of the speed reference which varies from 0 to 100 Hz.

[0033] The compensation curve can be further modified by adding or subtracting a constant value obtained from a trimmer, or by means of a coefficient which can be set by means of the processor; the interval of regulation of the speed is within 20%, whereas the direction of revolution of the motor 27 can be set by means of a dip-switch, or by means of the processor itself.

[0034] The electronic control unit 22 also has an input for connection of a temperature sensor, which is accommodated inside the motor 27; when the temperature of the windings exceeds a pre-determined value, distribution of energy is interrupted until the temperature drops below this limit. In these conditions, an LED diode, which shows the operating state, indicates the abnormality by switching on intermittently; after a predetermined number of blocks and re-starts (which can be set), within a specific period of time (which can be set), the vapour recovery system is stopped definitively.

[0035] A sensor to measure the ambient temperature can be connected as an alternative to the temperature sensor of the motor 27.

[0036] The power stage of the control unit 22 is provided with a sensor which measures the temperature, such that, when the temperature exceeds the value of approximately 85°C, distribution of energy to the motor 27 is stopped, and the LED diode which indicates the operating state lights; this condition continues until the temperature drops below this limit. In addition to thermal protection, there is also protection relating to the maximum current, which functions when a predetermined value of current intensity is exceeded, thus interrupting distribution of energy to the motor 27, and this distribution is then restored automatically after a number of attempts which can be programmed from a minimum of 1 to a maximum of 8.

[0037] The control unit 22 also has a serial communication gate of type RS485 for interfacing with an electronic processor and with a device for calibration and diagnosis of the system; in particular, according to preferred, but non-limiting embodiments, there is an asynchronous half/duplex serial interface of type RS485,

with 1200 bauds, 8 data bits, 1 stop bit and no parity.

[0038] In order to communicate with the electronic unit 22, it is necessary to have an electronic processor (personal computer), the minimum configuration of which is as follows: 486 microprocessor, 4 Mbytes of RAM memory, Windows 3.1 or later operative system, RS232-RS485 interface device; and the following parameters can be set via the processor:

- resolution of the input pulses generated by the pulse generator 20 (100/200 pulses per litre of fuel);
- encoder resolution of the motor 27 (2/4/8 pulses per revolution);
- direction of revolution of the motor 27 (clockwise/anti-clockwise) ;
- field of regulation of the speed of the pump 26 ($\pm 20\%$, from 5 to 60 litres of fuel per minute);
- manual speed regulation;
- fixed-revolution speed mode for the motor 27;
- field of regulation of the speed of the pump 26 with fixed revolutions (from 5 to 60 litres per minute);
- selection of fixed or variable revolution mode;
- number of compensation coefficients;
- allocation of the address for serial operating communication; and
- selection of the serial communication gate.

[0039] The main parameters which can be indicated are (in coefficients between 0 and 127);

- ambient temperature or temperature of the windings of the motor 27;
- temperature of the power stage of the unit 22;
- frequency of the input pulses (from 0 to 200);
- frequency of the pulses obtained from the encoder of the motor 27 (from 0 to 200);
- partial totalling of the fuel distributed (from 0 to 9999 litres);
- coefficients of correction (from 0 to 120);
- offset of the compensation curve (from 0 to 127, wherein the zero is determined by the number 64);
- position of the regulation trimmer;
- intensity of the current which circulates in the motor 27; and
- error code (from 1 to 8).

[0040] According to the present invention the electric motor 27 controls revolution of the vapour suction pump 26, at a speed which depends on the control signals which are received from the unit 22, and are converted into corresponding voltage signals to be supplied to the motor 27; in practice, the speed at which the motor 27 makes the pump 26 rotate, and thus the quantity of vapours recovered, depend on the voltage supplied to the motor 27.

[0041] It has already been seen that, in order to obtain the maximum efficiency of the recovery system 35, the control unit 22 must control the pump 26, such that the

vapour phase is recovered at a speed which corresponds to the volume of instantaneous vapour which is generated during an operation of filling the tank of a vehicle.

[0042] The unit 22 then determines an optimum instantaneous speed value for the suction pump 26, thus providing a non-linear function with several variables, which in turn depend on a set of independent variables, which are responsible for the variations in the volume of vapours generated during introduction of the fuel into the tank, i.e. by seeking the corresponding values in a matrix which is stored in a microprocessor.

[0043] The independent variables consist of the speed of distribution of the fuel, the volume of fuel distributed, the duration of the distribution, the ambient temperature, the temperature of the fuel, and any constrictions inside the return pipe 24 of the vapour phase. Other independent variables can be taken into consideration during the control procedure.

[0044] In order to determine the corresponding speed of the suction pump 26, the values of the independent variables must be measured instantaneously, by means of a series of sensors and transducers, and the corresponding signals relating to the dependent variables must be transmitted to the control unit 22.

[0045] In particular, there is construction by points of the flow rate/speed curve (P/v) relating to the suction pump 26 used, taking into account all the variables involved; thus, for example, a transducer for the flow of fuel transmits a signal proportional to the flow distributed, to the control unit 22, whereas the temperature transducers measure the ambient temperature and the temperature of the fuel, and transmit instantaneously a proportional signal to the unit 22.

[0046] An initial calibration of the vapour recovery system 35 is carried out by means of a sample pump 26, and the function which associates the variables of flow rate of vapour V (of recovery)/flow rate of liquid L (fuel distributed) is instantaneously determined by a microprocessor, in order, consequently to regulate the optimum speed of the motor 27, in relation with the variation of all the variables involved during an operation of supply which give rise to non-linearity of the function V/L.

[0047] In particular, in the embodiment of the wiring diagram illustrated in Figures 4A-4D relating to the control device according to the invention, there can be seen the connection pins of eight connectors used in an electronic card of a system for recovery of vapours, which is generally indicated by the reference 35 in Figure 3.

[0048] Figure 4A shows the electrical connections to the poles or pins P1-1, P1-2, P1-3, P1-6, P1-7, P1-8, P1-9, P1-10, P1-11, P1-12 of the connector P1 of the card, which permits transmission of the electrical signals from and towards the pulse generator (pulser) 20 or the CPU card of the electronic processor, the LED signalling diode, the temperature sensor, and the encoder of the brushless motor 27. In preferred, but non-limiting em-

bodiments, the 12-pole P1 connector is of the vertical male type, for example an MSTBVA 2,5/12-G-5, 08.

[0049] The poles P1-1 and P1-2 permit the connection with the pulse generator 20 (input signal, negative and positive pole respectively), whereas at the pin P1-3 there is available a supply (14.3 V, 100 mA) of the external pulser 20; in addition, the poles P1-8, P1-9 and P1-10 permit flow at the intake of the card, of the signals relating to the encoder of the motor 27 (according to the three spatial coordinates X, Y and Z respectively), whereas the pole P1-11 is connected to the positive pole (6.2 V) of the supply of the brushless motor 27, and the pole P1-12 represents a voltage reference of 0 V.

[0050] The poles P1-6 and P1-7 refer to inputs available and to a voltage reference of 0 V, whereas the pins J1-4 and J1-6 relate to a connector J1 of the 6-pole vertical pole male type, for example an AMP MODU1 280372-2, and constitute respectively an output pole for an isolated pulser signal towards an interface card (which is used if there is a vapour recovery system 35 for a multiple-product distributor, i.e. for a column 10 with several distributor pistols 18 for different products), and a pole relating to an input available.

[0051] Figure 4A also shows the connections to the pins P5-1, P5-2, P5-3, P5-4 of the 4-pole connector P5 of the vapour recovery electronic card; in particular, the connector P5 of the vertical male type, for example an AMP MODU2 280371-2, permits flow of the electrical signals from and towards the interface of the RS485 or RS422 type, or the programming terminal.

[0052] Thus, for example, the pole P5-1 is connected to the positive (5 V) supply of the interface, the poles P5-2 and P5-3 for input and output are connected to two lines in which the signals are transmitted from and towards the interface, whereas the pole P5-4 is reserved for the connection with the reference of 0 V.

[0053] Figure 4B illustrates the connections of the card to the pins P2-1, P2-2, P2-3, of the connector P2, of the 3-pole vertical male type, for example an MSTBVA 2,5/3-G-5, 08, and to the pins P1-4 and P1-5 of the connector P1; the poles P2-1, P2-2, P2-3 allow the electrical signals output to reach the brushless motor 27, and relate to the various phases of this electric motor 27, whereas the poles P1-4 and P1-5 permit output of an electrical signal relating to the supply (positive pole and negative pole) of a visual signal LED diode. The pin J1-5 of the connector J1 relates to a fault output signal.

[0054] Figure 4C shows the connections to the poles P3-1, P3-2, P3-3, P3-6, P3-7, P3-8, P3-9, P3-10, P3-11, P3-12 of the connector P3 (which is of the same type, and has the same functions as the connector P1), and of the poles J2-4 and J2-6 of the connector J2 (which is of the same type, and has the same functions as the connector J1).

[0055] Finally, Figure 4D shows the connections to the pins P3-4, P3-5 of the connector P3, the connections to the pins J1-1, J1-2, J1-3 of the connector J1, the connections to the pins J2-1, J2-2, J2-3, J2-5 of the con-

necter J2, the connections to the pins J3-1, J3-2 of the connector J3 (of the 2-pole vertical male type, for example an AMP MODU1 280609-2, which permits transmission of the signals from and towards the connector J1 and the 36 V supply of the electronic card for the vapour recovery), and the connections to the pins P4-1, P4-2, P4-3 of a connector P4 of the 3-pole vertical male type, for example an MSTBVA 2,5/3-G-5,0.8 which permits connection at the output to the electric motor 27, since the signals output control the phase.

[0056] Figure 5, which relates to a control wiring diagram for a digital brushless motor, shows the pins P1-1, P1-2 (relating to the inputs of the pulse generator 20), P1-3, P1-4 (relating to the outputs of the signalling LED), P1-5, P1-6 (relating to the connection of the temperature sensor), P1-7, P1-8, P1-9 (relating to other connections to sensor devices), and P1-10, P1-11, P4-1, P4-2 (relating to the direct current supply mains connection).

[0057] In addition, the pins P2-1, P2-2 and P2-3 relate to connections to the phases of the stator of the brushless motor, whereas the poles P3-1, P3-2, P3-3, P3-4 guarantee the connections to the serial line RS485.

[0058] In order to determine the function which associates the volume of vapour recovered (V) with the volume of liquid distributed (L), on the basis of a series of experimental data calculated by means of a vapour recovery system with a sample suction pump and presetting, the microprocessor 40 creates a table of values relating to the dependent variables, which are stored in a single or multi-dimensional matrix (contained in non-volatile memories), according to the number of independent variables on which the function $V=f(L)$ to be determined, depends.

[0059] The interval of values which each independent variable can assume can be selected such as to cover an appropriate measurable range during the entire supply operation; in addition, the microprocessor 40 uses the same table of values, and updates them for each successive operation of supply of fuel.

[0060] The independent variables can be selected such as to simulate in the best possible way the conventional operative conditions of a vapour recovery system, during the stage of filling the tank of a vehicle. For this purpose, it is also necessary to provide appropriate characteristics of capacity of the non-volatile memories used.

[0061] The determination of the function $V=f(L)$, which is rendered linear, is thus used to generate a signal to control the speed of a suction pump 26; finally, in order to provide more accurate control, the motor 27 is connected to the microprocessor 40 of the unit 22 by means of a feedback unit, such that, in this case, the feedback signal is transmitted from the motor 27 to the microprocessor 40, and the latter can generate the appropriate control signals for determination of the instantaneous speed of the pump 26, taking into account the feedback.

[0062] In practice, during an operation of filling with fuel by a user, the vapour recovery system 35 monitors

as variables the ambient temperature and the volume of fuel distributed. The ambient temperature is measured directly by a temperature transducer, and a corresponding signal is transmitted to the microprocessor 40 of the electronic unit 22, whereas the volume of fuel distributed is determined by measuring the flow, by means of a specific transducer; in fact, during distribution, the generator or pulser 20-transmits a series of pulses via the head 21, to the microprocessor 40, which stores in its memory the number of pulses which have been counted on completion of the operation of supply to the vehicle, and calculates the volume of fuel distributed on the basis of this number. The microprocessor 40 also continues to receive the signal fed back by the motor 27, in order to obtain accurate speed control of the pump 26, and to compensate for the lack of linearity.

[0063] The microprocessor 40 of the electronic control unit 22 can also include a timer device, which measures the time interval which elapses between two successive supplies, such that, if this time interval is greater than a specific pre-determined value, and thus the data stored (dependent variables) which relate to the experimental results, and are set on the V/L curve are not very accurate, new values of the variables are measured experimentally and stored in the electronic unit 22.

[0064] As an alternative to the solution previously described, according to a further non-limiting embodiment of the present invention, it is possible to store in the electronic unit 22 with a microprocessor 40, a table or matrix with 120 lines and two columns, wherein the first column contains the values relating to the frequency of input (in an interval of frequencies of between 0 and 100 Hz), corresponding to the signal obtained from the pulse generator 20, and the second column contains a series of output frequency values, corresponding to the number of revolutions at which the suction and vapour recovery pump 26 must function.

[0065] 120 lines of the matrix are provided, i.e. 20 more than the frequency interval 0-100 Hz, in order to be able to obtain a reasonable margin of regulation.

[0066] A regulation system of this type makes it possible to correct the characteristic curve of the suction pump 26, and the ratio V/L of the entire recovery system 35 for the vapours, if there is a different head downstream from the system 35.

[0067] The matrix is inserted in a corresponding non-volatile memory element (for example an EEPROM memory), integrated in the microprocessor 40, which makes it possible to preserve the data even when power is lacking, and also to be able to modify the data at any time.

[0068] The matrix is then completed by a series of data obtained experimentally from a sample assembly of suction pumps 26, such that the compensation curve is obtained by interpolation (a process which is carried out by an associated electronic processor), of some points at which the entire vapour recovery system 35 is tested.

[0069] The interpolation takes place by means of a

corresponding electronic calibration system, which can transfer the results obtained to the control unit 22 of the recovery system 35.

[0070] The vapour recovery system 35 in question can be regulated by means of a potentiometer (trimmer) present on the electronic card of the system 35, which makes it possible to translate a default curve stored in the microprocessor 40, i.e. which makes it possible, by translating this curve by means of transmission of a datum to the serial gate present on the electronic card of the recovery system 35, to exclude the trimmer function, and enable a register with the same functions as the trimmer.

[0071] By means of an external calibration device, which is connected to a measurer, it is also possible to simulate a series of distributions with various flow rates, the results of which are interpolated in order to obtain the characteristic curve, which is available directly on the electronic control unit 22.

[0072] Use of the electronic control device according to the invention can thus limit variation of the critical value required (the ratio V/L), when there is variation of the possible conditions of operation of the vapour recovery system; in fact, the main variation of the operating condition is caused by variation of the flow rate, which, for a mono-block distributor with a capacity of 50 litres/minute, can be considered variable between approximately 50 and 5 litres/minute. It will be appreciated that a qualitative measurement of the value of the vapour recovery system is provided by the fact that the curve V/L or L/V is as constant as possible within the field of operation, and an objective measurement of satisfaction consists of the greater or lesser variation of the parameter V/L, ie:

$$\Delta V/L = V/L \text{ max} - V/L \text{ min.}$$

[0073] The experimental results obtained have shown the full validity of the system according to the present invention; in fact, in addition to a vapour recovery system according to the invention, account has been taken of two conventional systems, for the purpose of quick, clear comparison of the data, i.e. a vapour recovery system with a pump with variable revolutions, which is controlled electronically (wherein the number of revolutions of the pump is proportional to the flow rate distributed, according to a constant of proportionality), and a system with a pump with fixed revolutions, which is controlled mechanically by the motor, and is provided with a proportional valve (wherein the number of revolutions of the pump is proportional to the number of revolutions performed by the motor, according to a constant of proportionality).

[0074] The Cartesian graph in Figure 6 relates to the experimental data for the ratio V/L (as a percentage), according to a series of values of flow rates (in litres/minute), which were obtained with a system using a

pump with fixed revolutions, controlled mechanically.

[0075] The Cartesian graph in Figure 7 additionally shows the experimental data of the ratio V/L (as a percentage), according to a series of values of flow rates (in litres/minute), which were obtained by means of a system using a pump with variable revolutions, controlled electronically.

[0076] When the graphs are compared, although it is obvious that in the case of a system using a pump with variable revolutions, controlled electronically, better performance is obtained than in the case of a system using a pump with fixed revolutions, controlled mechanically, it can be seen that, in terms of constancy of the ratio V/L, it is not possible by means of this system to eliminate completely the variation of V/L in the field of operation, as shown by the curve averaged to the experimental values obtained in Figure 7.

[0077] However, the latter curve makes it possible to obtain a curve of corrective calibration values to be used in the vapour recovery system according to the present invention, in order to linearise the response of the system. In fact, the graph in Figure 8 shows the curve of the corrective factors, when there is variation of the point of operation or flow rate Q, which can be used in the recovery system according to the invention: in this case, the number of revolutions of the pump used depends on the flow rate distributed.

[0078] The large number of points at which it is possible to evaluate the curve (approximately 100) permits virtually continuous linearisation of the system, thus providing close control of the ratio V/L or L/V throughout the field of operation; on the other hand, it can be seen that both the conventional recovery systems have serious limits at the ends of the field of operation (see Figures 6 and 7), which limits cannot be corrected under any circumstances except by using a control system of a non-linear type, as previously described.

[0079] The description provided makes apparent the characteristics of the device and method for controlling the recovery of the vapours in fuel distributor columns, and makes it clear that the device and method according to the invention have considerable advantages in comparison with the known art; at least the following of these deserve mention:

- speed of execution;
- maximal accuracy of results;
- lower costs, in terms of use, than according to the known art, as a result of the advantages obtained; and
- speed of setting and resolution of the control functions.

Claims

1. Method for controlling the recovery of the vapours in fuel distributor columns (10), which are capable

of distributing single or multiple products, each of said columns (10) comprising at least one suction pump (26) for the vapours, which is connected to an electric motor (27) having a speed of revolution depending on the basis of commands sent by an electronic control unit (22) as well as of direct or feedback signals sent by a pulse generator (20), via an electronic head (21), wherein said electronic unit (22) comprises processing means for processing a series of input signals, which is used in order to linearise a function from amongst variables related to the volume of vapour recovered by a vapour recovery system (35) and of fuel distributed by a delivery pumping unit (13), said processing means using at least one compensation curve, which, for a plurality of values, which are in turn determined by means of prior calibration of empirical values of said suction pump (26) and by means of at least one speed reference signal transmitted to the input of said electronic unit (22), determines an actual value of speed of said suction pump (26), said electronic unit (22) comprising a microprocessor (40), in which at least one table or matrix, containing values relating to an input frequency, corresponding to a signal obtained from said pulse generator (20), and relating to an output frequency, corresponding to a number of revolutions of said suction pump (26), is provided, said matrix being inserted in a non-volatile memory element of said microprocessor (40), **characterised in that** said matrix or table comprises data obtained experimentally from a series of samples taken by said suction pump (26), said compensation curve being obtained by means of an interpolation of a series of points at which said vapour recovery system (35) is tested, wherein said interpolation is carried out by means of an electronic calibration system, which transfers the results obtained to said electronic control unit (22).

2. Method for controlling the recovery of the vapours according to claim 1, **characterised in that** said matrix contains a plurality of regulation parameters, in order to correct said curve of the suction pump (26) and the ratio between the vapour recovered and the liquid delivered, with respect to the values of the head downstream of said recovery system (35), at least one potentiometer being used for translating a predetermined curve, stored in said microprocessor (40), by means of the following steps:

- transmission of data to a serial communication gate, interfacing with an electronic processor and with a calibration and diagnosis device, of said vapour recovery system (35);
- exclusion of said potentiometer; and
- enabling of a register having the same functions of said potentiometer.

3. Method for controlling the recovery of the vapours according to claim 1, **characterised in that** said pump (26) is controlled by said electronic unit (22), so that vapours are recovered at a speed which corresponds to a volume of vapour which is generated during an operation of supply of fuel, said electronic unit (22) determining at least one instantaneous speed value for said pump (26) by calculating a non-linear function with dependent variables, which are instantaneously measured, by means of a series of sensors and transducers, together with corresponding signals relating to said variables, which are transmitted to said electronic control unit (22), a plurality of values of independent variables being used in order to carry out initial calibration on a sample pump (26) and a function being determined between a flow rate of recovery vapour and a flow rate of fuel delivered in a given time unit, in order to regulate said motor (27) speed.
4. Method for controlling the recovery of the vapours according to claim 3, **characterised in that** said flow rate of fuel delivered is calculated by means of said generator (20), which, during the distribution of fuel, transmits a plurality of pulses, via said head (21), to said microprocessor (40), said microprocessor (40) storing a number of said pulses which is reached at the end of an operation of supply of fuel.
5. Method for controlling the recovery of the vapours according to claim 1, **characterised in that** said electronic control unit (22) includes a first input, which is connected to a temperature sensor situated inside said motor (27), and a second input, which is connected to a sensor for measuring the ambient temperature.

Patentansprüche

1. Verfahren zum Steuern der Rückgewinnung der Dämpfe in Kraftstoffzapfsäulen (10), die in der Lage sind, einzelne oder mehrere Produkte zu verteilen, wobei jede der Säulen (10) mindestens eine Saugpumpe (26) für die Dämpfe umfasst, die mit einem Elektromotor (27) verbunden ist, der eine Drehgeschwindigkeit aufweist, die abhängig ist von Befehlen, die von einer elektronischen Steuereinheit (22) gesendet werden, sowie von direkten oder Rückkopplungssignalen, die von einem Impulsgenerator (20) über einen elektronischen Kopf (21) gesendet werden, wobei die elektronische Einheit (22) ein Verarbeitungsmittel zum Verarbeiten einer Reihe von Eingangssignalen umfasst, das dazu verwendet wird, eine Funktion zwischen Variablen zu linearisieren, die mit dem Volumen von Dampf, der von einem Dampfrückgewinnungssystem (35) rückgewonnen wird, und von Kraftstoff, der von einer Ab-

gabepumpeneinheit (13) verteilt wird, in Beziehung stehen, wobei das Verarbeitungsmittel zumindest eine Kompensationskurve verwendet, die für eine Vielzahl von Werten, die wiederum mittels einer vorhergehenden Kalibrierung von empirischen Werten der Saugpumpe (26) und mittels zumindest eines zum Eingang der elektronischen Einheit (22) übertragenen Drehzahlreferenzsignals bestimmt werden, einen Ist-Drehzahlwert der Saugpumpe (26) bestimmt, wobei die elektronische Einheit (22) einen Mikroprozessor (40) umfasst, in dem zumindest eine Tabelle oder Matrix vorgesehen ist, die die Werte enthält, die mit einer Eingangsfrequenz, die einem von dem Impulsgenerator (20) erhaltenen Signal entspricht, in Beziehung stehen, und mit einer Ausgangsfrequenz, die einer Anzahl von Umdrehungen der Saugpumpe (26) entspricht, in Beziehung stehen, wobei die Matrix in ein nichtflüchtiges Speicherelement des Mikroprozessors (40) eingegeben wird, **dadurch gekennzeichnet, dass** die Matrix oder Tabelle Daten umfasst, die experimentell aus einer Reihe von Proben, die von der Saugpumpe (26) genommen wird, erhalten werden, wobei die Kompensationskurve erhalten wird mittels einer Interpolation einer Reihe von Punkten, an denen das Dampfdruckgewinnungssystem (35) geprüft wird, wobei die Interpolation mittels eines elektronischen Kalibrierungssystems ausgeführt wird, das die erhaltenen Ergebnisse an die elektronische Steuereinheit (22) übermittelt.

2. Verfahren zum Steuern der Rückgewinnung der Dämpfe nach Anspruch 1, **dadurch gekennzeichnet, dass** die Matrix eine Vielzahl von Regelparametern enthält, um die Kurve der Saugpumpe (26) und das Verhältnis zwischen dem rückgewonnenen Dampf und der abgegebenen Flüssigkeit in Bezug auf die Werte des Kopfes unterstromig des Rückgewinnungssystems (35) zu korrigieren, wobei zumindest ein Potentiometer zur Übersetzung einer vorbestimmten, in dem Mikroprozessor (40) gespeicherten Kurve verwendet wird, mittels der folgenden Schritte:

- Übertragen von Daten zu einem seriellen Kommunikationsgatter, Schnittstellenbildung mit einem elektronischen Prozessor und mit einer Kalibrierungs- und Diagnoseeinrichtung des Dampfdruckgewinnungssystems (35);
- Ausschluss des Potentiometers; und
- Freigabe eines Registers, das die gleichen Funktionen wie das Potentiometer aufweist.

3. Verfahren zum Steuern der Rückgewinnung der Dämpfe nach Anspruch 1, **dadurch gekennzeichnet, dass** die Pumpe (26) durch die elektronische Einheit (22) derart gesteuert wird, dass die Dämpfe

mit einer Geschwindigkeit rückgewonnen werden, die einem Dampfvolumen entspricht, das während eines Kraftstoffversorgungsbetriebes erzeugt wird, wobei die elektronische Einheit (22) zumindest einen momentanen Drehzahlwert für die Pumpe (26) bestimmt, indem eine nichtlineare Funktion berechnet wird mit abhängigen Variablen, die momentan mittels einer Reihe von Sensoren und Wandlern gemessen werden, zusammen mit entsprechenden Signalen, die mit den Variablen in Beziehung stehen und zu der elektronischen Steuereinheit (22) übertragen werden, wobei eine Vielzahl von Werten von unabhängigen Variablen dazu verwendet wird, eine Anfangskalibrierung an einer Probepumpe (26) auszuführen, und wobei eine Funktion zwischen einem Durchfluss von Rückgewinnungsdampf und einem Durchfluss von in einer gegebenen Zeiteinheit abgegebenem Kraftstoff bestimmt wird, um die Drehzahl des Motors (27) zu regeln.

4. Verfahren zum Steuern der Rückgewinnung der Dämpfe nach Anspruch 3, **dadurch gekennzeichnet, dass** die Strömungsrate von abgegebenem Kraftstoff mittels des Generators (20) berechnet wird, der während der Verteilung des Kraftstoffes eine Vielzahl von Impulsen über den Kopf (21) zu dem Mikroprozessor (40) überträgt, wobei der Mikroprozessor (40) eine Anzahl der am Ende eines Kraftstoffversorgungsbetriebes erreichten Impulse speichert.
5. Verfahren zum Steuern der Rückgewinnung der Dämpfe nach Anspruch 1, **dadurch gekennzeichnet, dass** die elektronische Steuereinheit (22) einen ersten Eingang umfasst, der mit einem sich im Inneren des Motors (27) befindlichen Temperatursensor verbunden ist, und einen zweiten Eingang umfasst, der mit einem Sensor zum Messen der Umgebungstemperatur verbunden ist.

Revendications

1. Procédé pour contrôler la récupération des vapeurs dans des colonnes de distribution de carburant (10), qui sont capables de distribuer des produits uniques ou multiples, chacune desdites colonnes (10) comprenant au moins une pompe d'aspiration (26) pour les vapeurs, qui est reliée à un moteur électrique (27) ayant une vitesse de révolution dépendant de la base des commandes envoyées par une unité de commande électronique (22) ainsi que de signaux directs ou de retour émis par un générateur d'impulsions (20), via une tête électronique (21), dans lequel ladite unité électronique (22) comprend des moyens de traitement pour traiter une série de signaux d'entrée, qui est utilisée pour linéariser une fonction parmi des variables relatives au

volume de la vapeur récupérée par un système de récupération de vapeur (35) et du carburant distribué par une unité de pompage de refoulement (13), lesdits moyens de traitement utilisant au moins une courbe de compensation, qui, pour une pluralité de valeurs, qui sont tour à tour déterminées au moyen d'un calibrage préalable de valeurs empiriques de ladite pompe d'aspiration (26) et au moyen d'au moins un signal référence de vitesse transmis à l'entrée de ladite unité électronique (22), détermine une valeur réelle de la vitesse de ladite pompe d'aspiration (26), ladite unité électronique (22) comprenant un microprocesseur (40) dans lequel au moins une table ou matrice, contenant des valeurs relatives à une fréquence d'entrée, correspondant à un signal obtenu depuis ledit générateur d'impulsions (20), et relatives à une fréquence de sortie, correspondant à un certain nombre de révolutions de ladite pompe d'aspiration (26), est prévue, ladite matrice étant insérée dans un élément de la mémoire non volatile dudit microprocesseur (40), **caractérisé en ce que** ladite matrice ou table comprend des données obtenues expérimentalement par une série d'échantillons pris par ladite pompe d'aspiration (26), ladite courbe de compensation étant obtenue au moyen d'une interpolation d'une série de points auxquels ledit système de récupération de vapeur (35) est testé, dans lequel ladite interpolation est réalisée au moyen d'un système de calibrage électronique, qui transfère les résultats obtenus à ladite unité de commande électronique (22).

2. Procédé pour contrôler la récupération des vapeurs selon la revendication 1, **caractérisé en ce que** ladite matrice comprend une pluralité de paramètres de régulation, afin de corriger ladite courbe de la pompe d'aspiration (26) et le rapport entre la vapeur récupérée et le liquide amené, par rapport aux valeurs de la tête en aval dudit système de récupération (35), au moins un potentiomètre étant utilisé pour traduire une courbe prédéterminée, stocké dans ledit microprocesseur (40), au moyen des étapes suivantes :

- transmission de données à une passerelle de communication en série, interfaçant avec un processeur électronique et avec un dispositif de diagnostic et de calibrage, dudit système de récupération de vapeur (35) ;
- exclusion dudit potentiomètre ; et
- activation d'un registre ayant les mêmes fonctions que ledit potentiomètre.

3. Procédé pour contrôler la récupération des vapeurs, selon la revendication 1, **caractérisé en ce que** ladite pompe (26) est contrôlée par ladite unité électronique (22), de telle sorte que les vapeurs sont récupérées à une vitesse qui correspond à un

volume de vapeur qui est généré lors d'une opération d'alimentation en carburant, ladite unité électronique (22) déterminant au moins une valeur de vitesse instantanée pour ladite pompe (26) en calculant une fonction non linéaire avec des variables dépendantes, qui sont mesurées instantanément, au moyen d'un ensemble de capteurs et transducteurs, de pair avec des signaux correspondants relatifs auxdites variables, qui sont transmises à ladite unité de commande électronique (22), une pluralité de valeurs de variables indépendantes étant utilisée afin de réaliser un calibrage initial sur une pompe de calibrage (26) et une fonction étant déterminée entre un débit de vapeur récupérée et un débit de carburant amené dans une unité de temps donnée, afin de réguler la vitesse dudit moteur (27).

4. Procédé pour contrôler la récupération des vapeurs selon la revendication 3, **caractérisé en ce que** ledit débit de carburant amené est calculé au moyen dudit générateur (20), qui, pendant la distribution de carburant, transmet une pluralité d'impulsions, via ladite tête (21), audit microprocesseur (40), ledit microprocesseur (40) stockant un certain nombre desdites impulsions qui est atteint à la fin d'une opération d'alimentation en carburant.

5. Procédé pour contrôler la récupération des vapeurs selon la revendication 1, **caractérisé en ce que** ladite unité de commande électronique (22) comprend une première entrée, qui est reliée à un capteur de température situé à l'intérieur dudit moteur (27), et une seconde entrée, qui est reliée à un capteur pour mesurer la température ambiante.

Fig.1

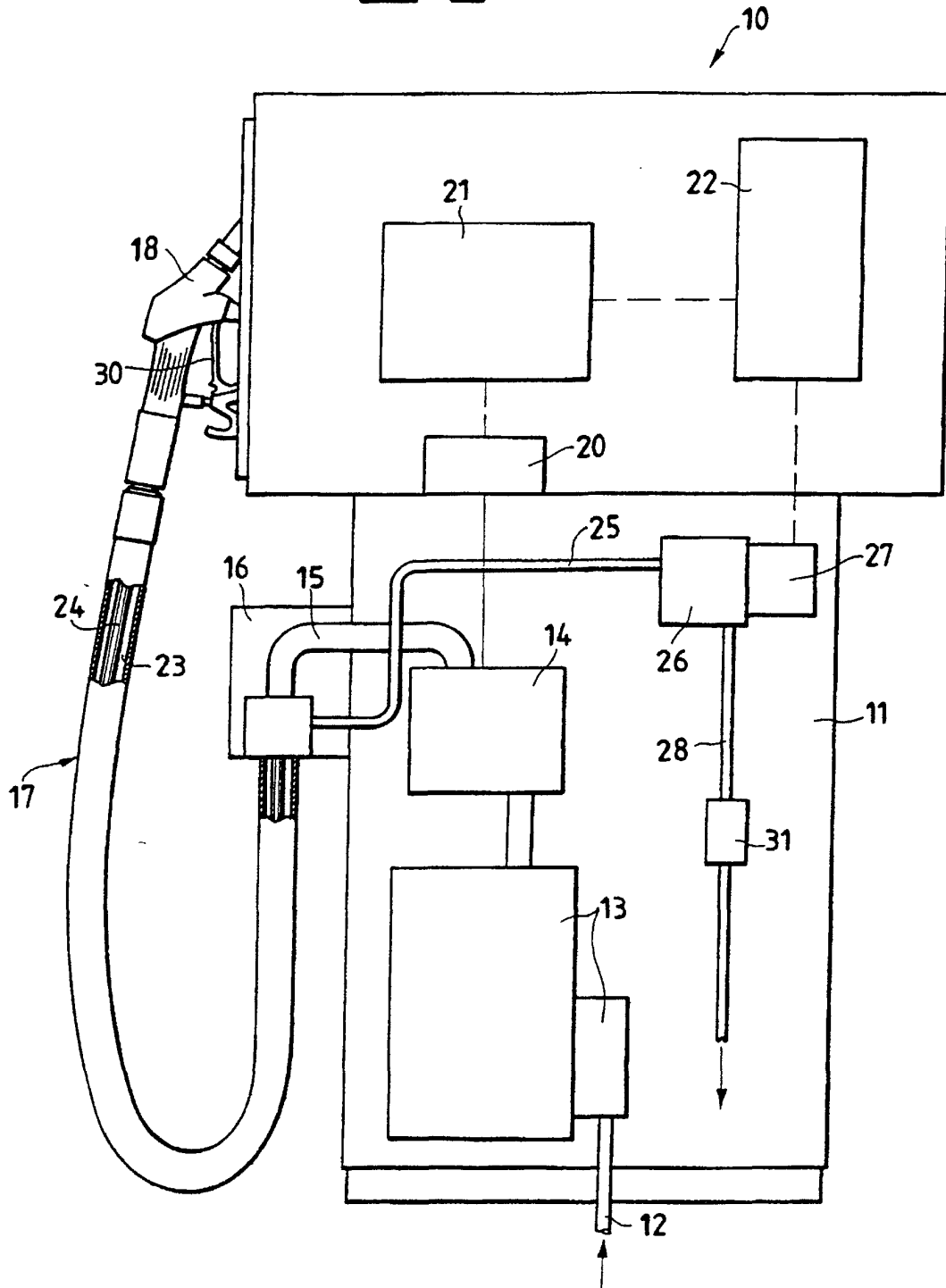


Fig.2A

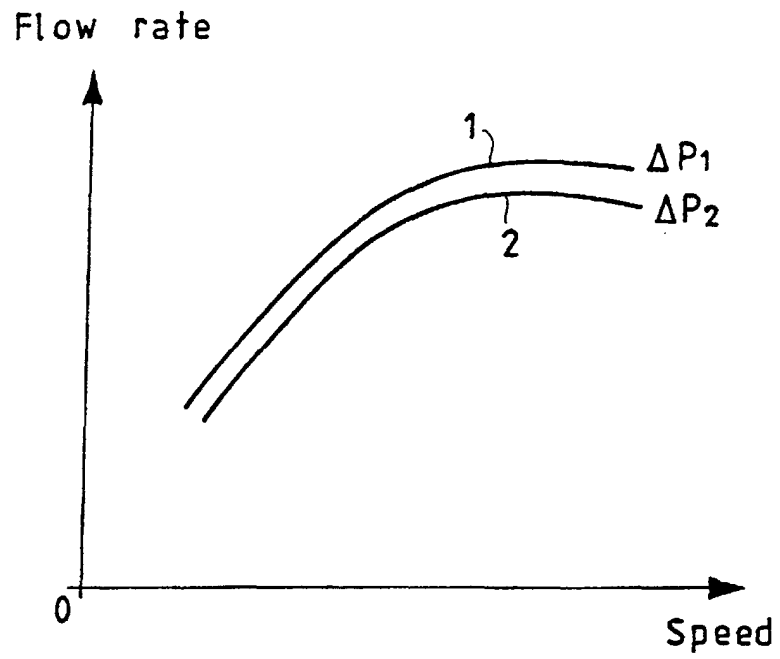


Fig.2B

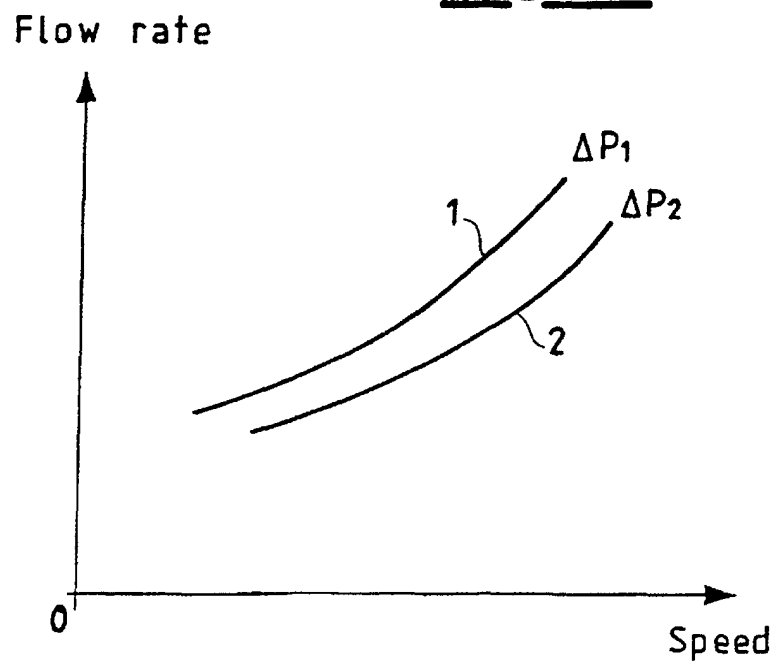


Fig.3

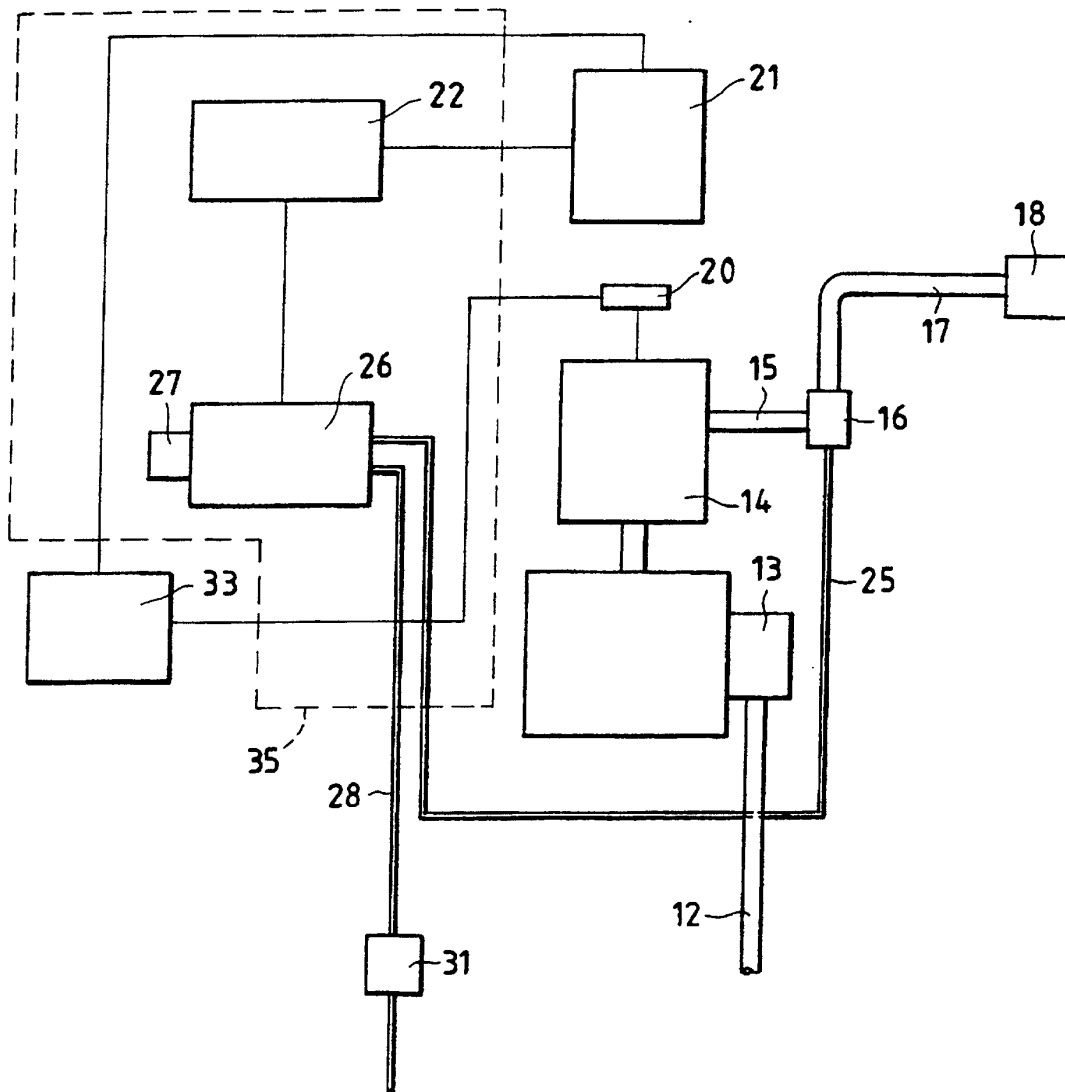
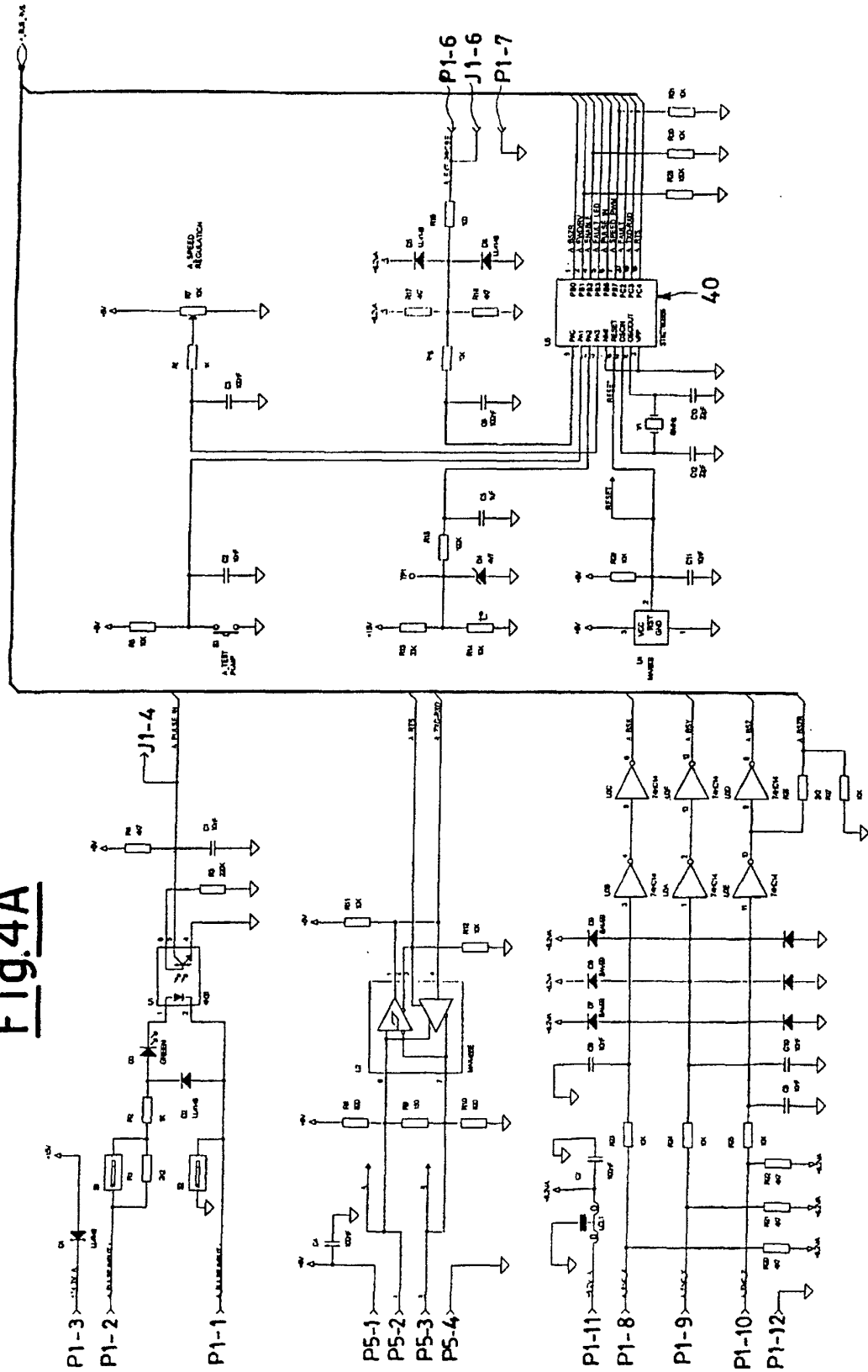
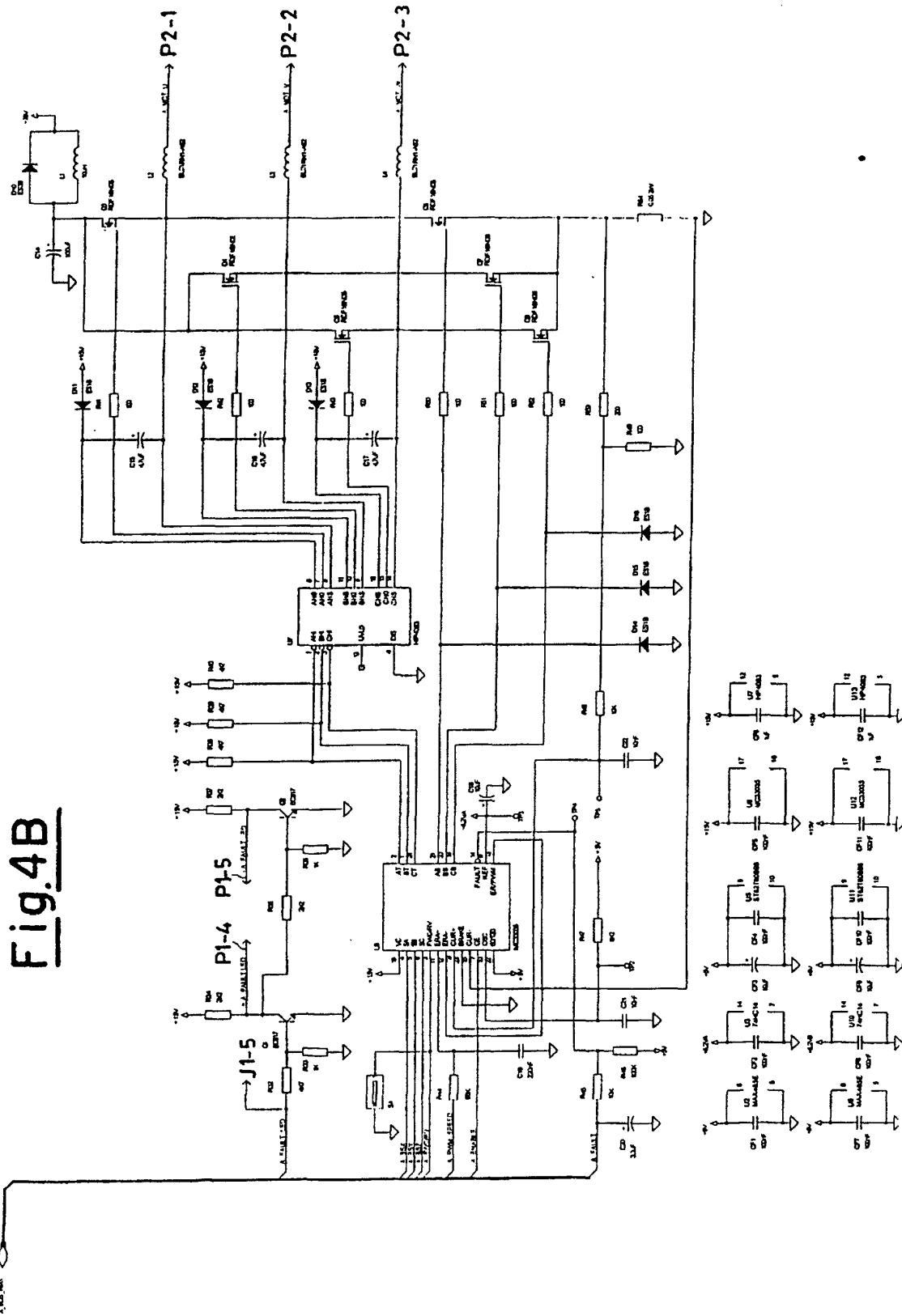
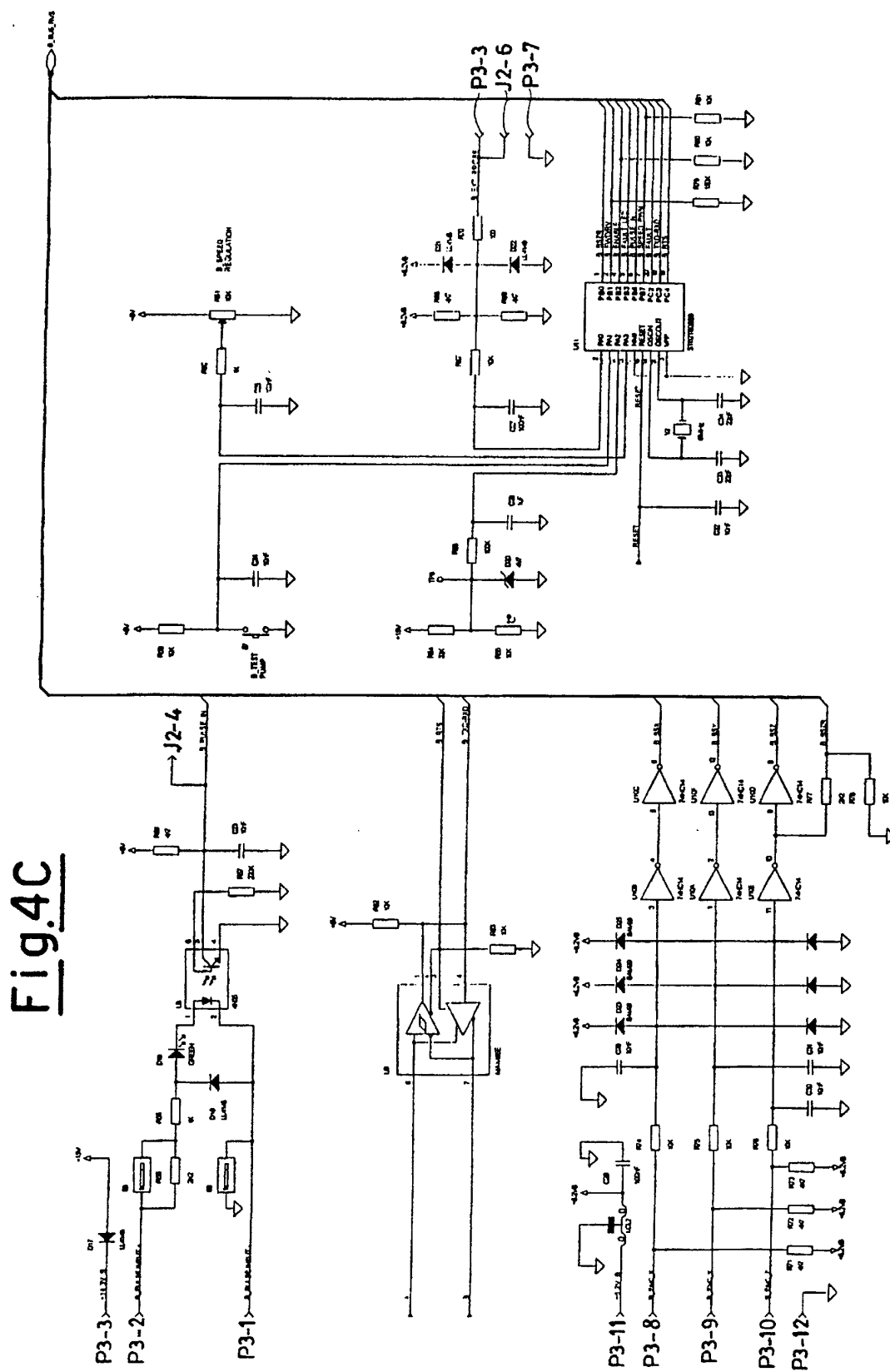
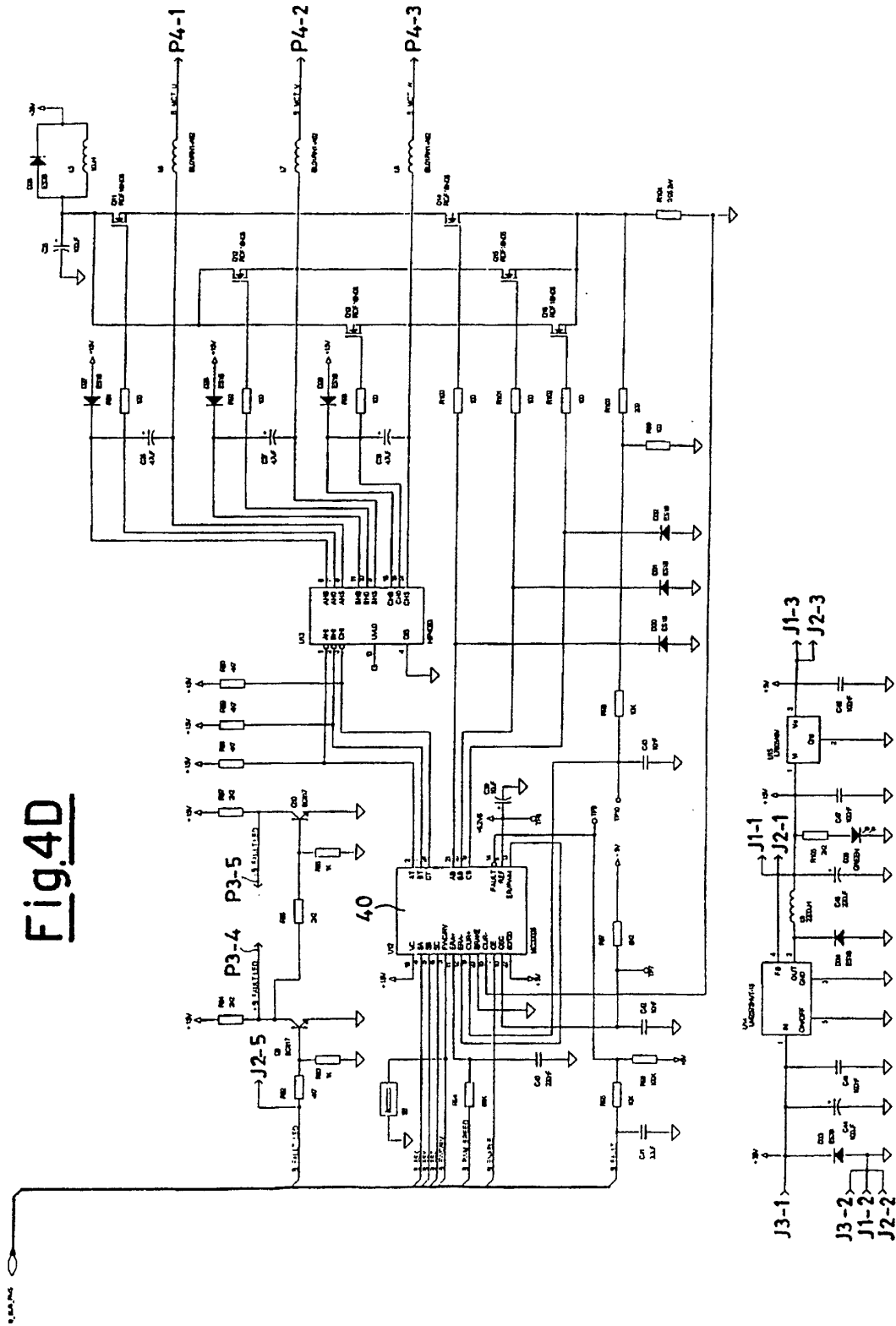


Fig.4A









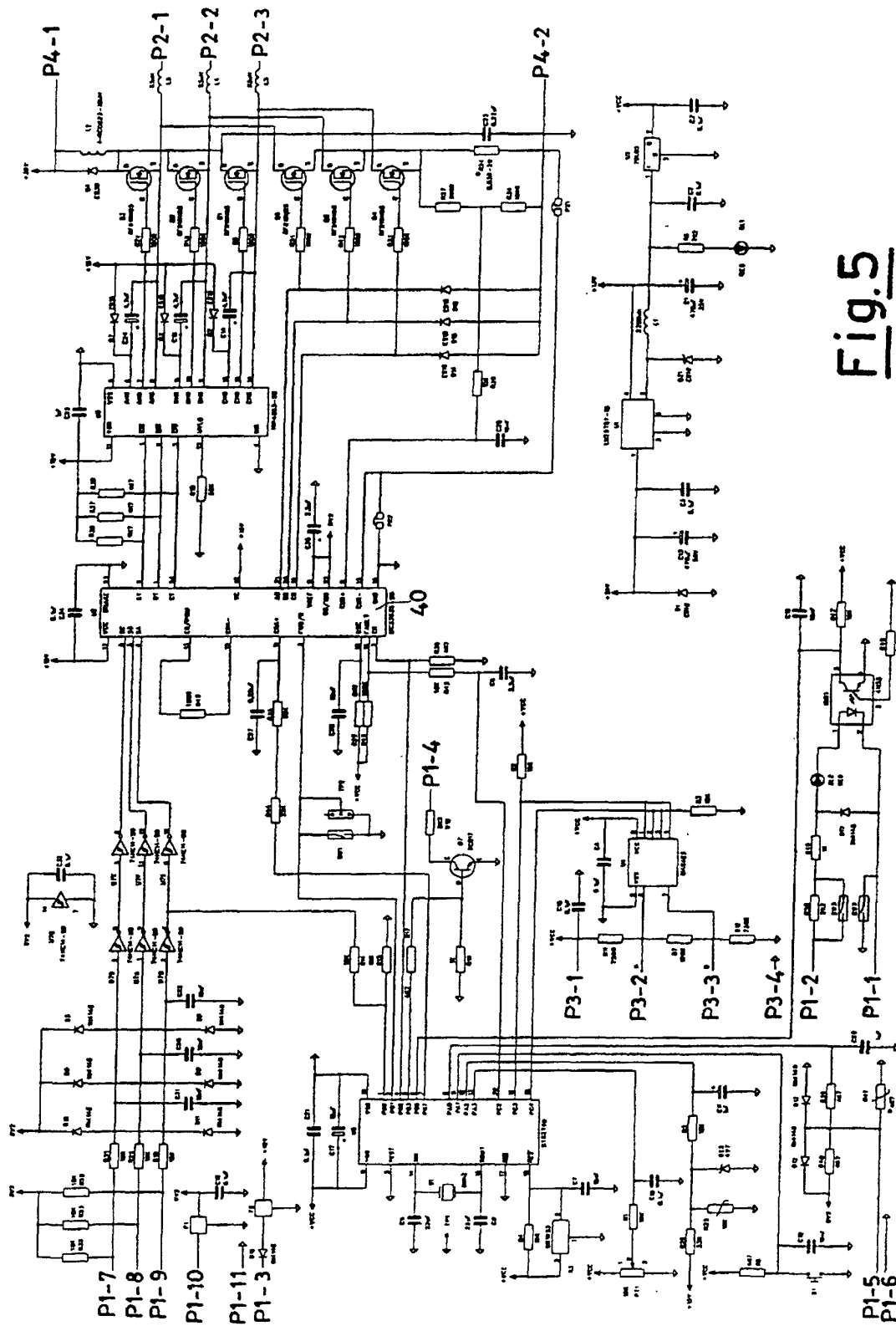


Fig.5

