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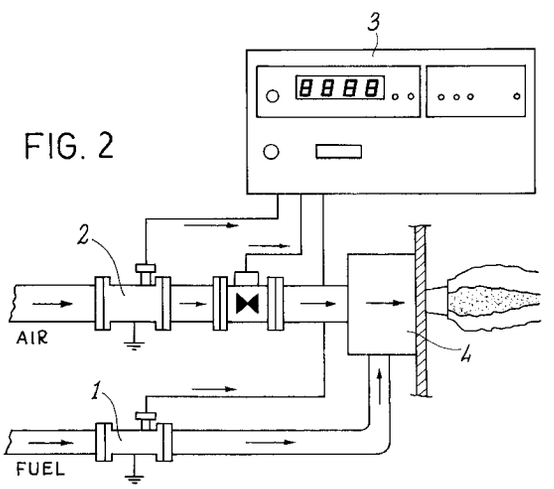
(54) Air-fuel ratio control device for heat generators, particularly for civil plants.

(57) This invention relates to a device for controlling the fuel/comburant ratio in heat generators, in particular for civil plants, said device comprising a first fuel flowrate sensor (1) which is sensitive to the mass flowrate and is capable of transducing the presence/absence of network at the terminals of the fuel flowrate control means into an ON/OFF electric signal, a second comburant flowrate sensor (2) which is sensitive to the mass flowrate, a transduction, control and actuation electronic member (3) which is capable of determining the operation of the device itself on the basis of values set forth in the start step and on the basis of the signals that arrive from the two sensors, and a motorized control means (9) which, following a command of an electric impulse sent by said electronic member (3) opens or closes the opening for the passage of comburant air so as to keepthe fuel/comburant ratio constant.

FIG. 2



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This invention relates to a device for controlling the fuel/comburant ratio in heat generators, in particular for civil plants.

More particularly, this invention relates to a device of the type mentioned above, which is capable of keeping constant under certain conditions the fuel/comburant ratio in gas oil plants, or in fuel oil and gas plants, so increasing the energic efficiency of the plant and reducing the amount of polluting matter discharged into the atmosphere.

As is well known, the complete and normal combustion of liquid fuels is ensured by the transformation of such fuels into the vapour state, so that they can become intimately mixed with the correct amount of air.

This process is realized by the burner that has the task of introducing the liquid fuel into the combustion chamber in the form of very fine droplets which, heated up by the flame itself, evaporate. The complex molecules of the vapourized fuel have a tendency to split into simpler and hence lighter molecules, so giving rise to ignition, or to the combination of hydrogen and carbon with the oxygen which is present in the comburant air. Combustion air is supplied partly as primary air at the base portion of the flame, and partly as secondary air around the same, by means of an electric fan. The calibration of the comburant air flowrate which is necessary for setting forth the correct value of excess air is obtained by acting on a suitable control gate.

However, the characteristics of the fuel sources are always kept under control so that the contribution to the combustion process can always be foreseen, whereas in the case of the comburant the things are just a different way.

Indeed, it has been ascertained that, with a determined flowrate of fuel, the total effective comburant power of air depends on its density (i.e. on the mass per unit volume) and this amount is quite remarkably variable according to the atmosphere pressure and temperature conditions, both temperature and pressure of the atmosphere being foreseeable just within their seasonal variation range but not as regards their momentary values.

Figure 1 shows the behaviour of air density curves as a function of temperature and pressure, with respect to the nominal value (1.2 kg/m^3 at 1,013 mbar and 20°C).

Consequently, a burner callibrated exactly under certain environmental conditions will work out of calibration as soon as such conditions will be changed. For instance, the only temperature change between day and night gives rise to systematic percentage changes of remarkable values even if the pressure is supposed to keep constant.

At present, the operation of controlling combustion is carried out through systems which are purposely studied for industrial type applications, or anyway for applications stemming from them directly.

Such systems consist in the adjustment of the fuel or comburant flowrate by different means, acting on the basis of information supplied by sensor means which analyse combustion smokes, as for instance O_2, CO, CO_2 analysers, of the smoke temperature, which are able to detect the necessary information for calculating the efficiency of combustion.

By means of such systems, the calculation is substantially carried out of combustion efficiency as well as of flowrate adjustment according to a strategy of the search for optimal values.

Accordingly, the well known systems adopt devices that autonomously provide for optimization of combustion efficiency according to more or less efficient automatic strategies. Thus in the hypothesis of a perfect functionality, compensation is obtained of almost whole perturbatrice phenomena of the optimal combustion ratio, as for instance human errors in calibrating the combustion ratio, the shift effects due to soiling of stacks and flues and chimneys, changes in the comburant oxygen percentage in atmospheric air, ovalization of nozzles, with consequent changes in fuel flowrate, the slow and/or fluctuation drifts of feeding pressures of fuel, with consequent changes in the flowrate of the fuel itself, changes in atmospheric pressure and temperature and changes in the climate and weather conditions, with consequent changes in the comburant flowrate and the efficiency drifts and/or changes of transduction mechanical members for motion (electric motors), or in voltages of frequencies of electric supplies, with consequent changes in pump and blower heads and the relative fuel and/or comburant flowrate changes.

Though such approach is correct from a principle standpoint, as a matter of fact it has limited the wide employment of technologies for controlling combustion just to rare cases concerning industrial applications of remarkable potential, because of the high costs of the systems for analysing smokes, of their poor reliability and of their difficult maintenance, as well as of calibration and management. Indeed, their employment in civil works is practically null.

The Applicant, being well aware of the problems mentioned above, thought of realising a device whose efficiency is practically equal to that of the already existing devices, but that can at the same time be applied also in plants for civil use because of its low cost, and extremely simple to assemble and that asks practically for no maintenance.

Such results have been reached by realizing a device in which the compensation of some of the perturbative factors mentioned above has been renounced, so dispensing with the costly sensor devices for analyzing smokes, but without renouncing the quality of the resulting product because the factors neglected have practically no influence, especially in most of civil applications.

The device according to this invention is based in practice on the adjustment of the fule/comburant ratio by keeping it constant in time and at a value corresponding to that which is obtained through the manual adjustment at the moment when the burner is started.

Thus a lower number of information is required, because the only information necessary continously is that concerning the flowrate of fuel of comburant.

The adjustment of this ratio occurs by acting on an adjustment means which is inserted on the heat generator burner air intake.

Such results are obtained, according to the present invention, through a continuous control of the fuel/comburent ratio, which is kept constant also when the thermo-dynamic characteristics of fuel or of the comburant change. Such control is realized by detecting continuously the effective values of the mass flowrates of the comburant and of the fuel.

The device according to this invention allows the dispersion of the comburant/fuel ratio values within an error range of ± 1 % of the optimal value.

Accordingly, it is a specific object of this invention a device for controlling the fuel/comburant ratio in heat generators, in particular for civil plants, said device comprising a first fuel flowrate sensor which is sensitive to the mass flowrate and is capable of transducing the presence/absence of network at the terminals of the fuel flowrate control means into an ON/OFF electric signal, a second comburant flowrate sensor which is sensitive to the mass flowrate, an electronic transduction, adjustment and actuation member which is capable of determining the operation of the apparatus on the basis of the values set forth when starting the operation as well as of the signals that arrive from the two sensors, and a motorized adjustment means which, when commanded by an lectric pulse sent by said electronic member, opens or closes the opening for the passage for the comburant air so as to keep the fule/comburant ratio constant.

Said transduction, adjustment and actuation electronic member will comprise, according to a preferred embodiment of the device of this invention, at least a display, a plurality of precision adjustment members, a plurality of push buttons, a plurality of light indicators, at least two analogue inputs for the signal concerned with the comburant flowrate and the signal concerned with the fuel flowrate respectively, at least two digital inputs for the boiler thermostat signal and the burner electric valve signal respectively, and at least four digital outputs for the feeding of an air and gas oil probe, the feeding of a gas oil flowrate probe, the anticlockwise rotation of the motorized strap and the clockwise rotation of the same, respectively.

Again according to the present invention, said electronic member can be provided with an asynchronous serial gate for connection to a processor.

Moreover, according to this invention, two further analogical inputs can be provided respectively for the smoke temperature and the outer temperature, and an impulsive input for the control of gas meters.

According to a particularly preferred embodiment of the device of this invention, a display, five precision adjustment means or trimmers, three push buttons and five light indicators are provided.

This invention will be disclosed now according to some preferred embodiments of the same with particular reference to the figures of the enclosed drawings, wherein:

Figure 2 is a schematic view of the device according to this invention;

Figure 3 shows a schematic view that illustrates the operation of the device according to this invention; and

Figure 4 shows schematically the outer view of the apparatus according to this invention.

The device according to this invention comprises (see Figures 2 and 3) a fuel flowrate sensor 1 which is sensitive to the mass flowrate and is capable of transducing the presence/absence of network at the terminals of the electric valve (not shown) for controlling the fuel flowrate into an ON/OFF electric signal.

Moreover, such device comprises a comburant flowrate sensor 2, which is sensitive to the mass flowrate, and a transduction, adjustment and actuation electronic member, which is endowed with an inner storage device capable of keeping for a practically unlimited time the values of the flowrates measured by said sensors 1 and 2 when the system is started, and capable of receiving the signals from said sensors 1 and 2, as well as of realizing a constant adjustment algorithm and of controlling the ouptut towards the actuator 4. Such member 3 is provided with auxiliary devices, like a display 5 for visuallizing messages and the values useful to the human operator, and with push buttons 6, pilot lights 7 and adjustment potentiometres 8. Such functions (storage included) are realized in a virtual way through a microprocessor system endowed with a programme (Firmware) and with suitable interfaces, as well as a mororized strap 9, which as a matter of practice is an electromechanical actuator that, on command of an electric impulse opens or closes an opening for the passage of comburant air.

The device according to this invention stores on command of the human operator the values of the fuel and the comburant flowrates when the system is started. It is supposed that the operator, after adjusting the burner-generator 4 group optimally, employing a conventional hand-operated set of tools, gives the machine the order of "storing" such values for future use.

Next a further order starts the device according to this invention. From this moment afterwards, it will act on the adjustment means 9 so as to keep the measured combustion ratio equal to that which has

been stored.

The member 3, which is shown schematically in Figure 4, is a tight-seal container with a transparent cover having two electronic cards.

The first one, i.e. the upper card 10, is provided with the display 5, three push buttons 6, five pilot lights or leds 7 and five adjustment potentiometres or trimmers 7.

By means of the display 5 the alarm conditions are visualized and the values of the working quantities are shown so that all such values can be easily changed by means of the trimmer 8 and the push buttons 6.

The device is further endowed with an analogue input for air flowrate, an analogue input for gas oil flowrate, a digital input for the boiler thermostat, and a digital input fot the burner electric valve.

Moreover, four digital outputs are also provided respectively for feeding the air and gas oil probe, for activating the gas oil flowrate probe, for the anticlockwise rotation of the means 9 and the clockwise rotation of the same.

Two further analogue inputs and an impulsive input are also provided in case the smoke temperature and the outer temperature or possibly the control of gas metres are to be respectively detected and controlled.

Finally, an asynchronous gate RS-232 is provided for connecting the device to a computer.

As regards the anallogue inputs, the two first inputs are employed for measuring the gas oil and air fllowrates whereas the two other inputs can be employed just following a future expansion of the system itself, and they allow the smoke temperature and the outer temperature to be measured.

Of the two digital imputs, the first allows the zero value of the gas oil sensor 1 to be stored during the stop periods of the burner 4, while the second input allows the consumption of fuel and the air/gas oil ratio to be controlled.

As regards the digital output, the first one serves the purpose of feeding the air and gas oil flowrate probes, while the second one is to activate the gas oil flowrate probe, and finally the least two serves the purpose of modifying, through the actuation of a clockwise or anticlockwise rotation, the position of the adjusting means 9. Such means 9, which is an actuation to the means of the plant, has the function of controlling the air flowrate to the burner 4, by increasing or decreasing according to the requirements the opening angle of the same.

The trimmers 8 (which are pointed out in Figure 4 as T1, T2,..., T5) perform a very important function in the starting phase of the device; indeed, as they are completely assimilable to analogue inputs they are capable of receiving and memeorizing some parameters which are absolutely resuired for controlling the plant itself. The hardware level storing of such data is useful in case of lack of supply for resetting the input parameters. On the other side, the introduction of the values through the rotation of the trimmers 8 makes it much easier to perform the starting operations with respect to any possible introduction from the keyboard.

In particular, the two "storage" trimmers 8 (T1 and T4) are employed for memorizing through the values of air and gas oil flowrate the combustion ratio; the "stability trimmer 8 (T2) allows the range (dead range) to be widened within which the combustion ratio can change without intervention of control; the "gain" trimmer 8 (T3) allows the rotation duration (gain) to be controlled of the means 9 for each impulse received; the "contrast" trimmer 8 (T5) finally allows the luminosity of the display 5 to be changed.

Thee three push buttons 6 (P1, P2 and P3) that the member 3 is endowed with, perform different functions according to the state in which the device according to this invention is found. The simultaneous pushing of the three push buttons 6 causes, if the device is in the alarm state, the resetting of the state itself; in all other cases, by pressing simultaneously the push buttons 6, the resetting is obtained of all stored values.

The leds 7 (L1, ..., L5) are employed for displaying immediatly some operations that the device is performing, as well as the state of the device itself; the function of said leds 7, and the function of the push buttons 6, both depend on the state of the device.

The device according to the present invention pan control the combustion and it can also perform the distribution of consumptions.

The auxiliary functions such as the supply transformer and the input interface are contained on the second lower card.

The control of combustion is carried out by the device keeping constant the ratio between the air flowrate and the gas oil flowrate in the burner; such ratio is kept equal to an optimal value set forth by the operator in the starting phase.

More particularly, the ways for carrying the control process into effect are the following: the device, when the plant is on, measures continuously the air and the gas oil flowrates and controls the two flowrates so that their ratio (the combustion ratio) is equal to the value already set forth, inside a given range. If the measured ratio is different from that set forth in advance, the device changes the flowrate by acting on the strap 9.

Any air defect or excess is signaled also to the operator by the lighting of the leds 7, L2 or L3, which point out the fact that an action is in progress on the control means 9, according to the fact that the combustion ratio is higher or lower than the value stored.

As regards the distribution of consumptions, the device stores for each day of the year the total flowrate of gas oil and the values of consumption.

Thus one can have at disposal the consumption bahaviour and the time distribution of consumptions themselves.

During its operation, the device can be in a definite state according to the task it is performing. More particularly, the operational states are:

- normal operation
- the alarm state
- the clock adjustment
- the consumption distribution
- the calibration

The normal operation state is that in which the device operates during the process control, when no alarm occurs. Such state is put into evidence by the constant fixed lighting of the led 7 L2; then the leds 7 L1 and L3 can light; the lighting of such leds 7 points out that an action is in progress on the control means 9 for performing a rotation respectively in the clockwise and the anticlockwise sense and then for decreasing or increasing the air flowrate. It is possible that during the control action the means 9 performs oscillations, but such drawback can be removed through the trimmer 8 T2 and/or the trimmer 8 T3, by suitably changing the dead band and/or gain.

During normal operation, the display 5 visualizes a series of messages that give indications about the operations in progress. The first line always displays the date and time; the second line changes according to the state of the plant. When the burner 4 is off, the display visualizes the "zero value" as volts of the gas oil probe as well as the number of seconds passed since the last updating of such value. When the state of the thermostat becomes ON, the last value of the zero stored with the burner 4 in the off state is reported. When the burner 4 is on, after a thirty seconds waiting time (which is necessary for obtaining the first reading), which is signaled on the displays 5, the measured combustion ratio and the combustion ratio set forth in advance are visualized.

The alarm state is that in which the device is found when an alarm occurs owing to a sensor 1 or 2 which is outside range due to a wrong operation of the probe. The presence of an alarm is signaled by the content fixed lighting of the led 7 L4 and by the simultaneously blinking of the leds 7 L1 and L3, in addition to be signalled on the display 5. All push buttons 6 are inactivated till the alarm is present. When the alarm condition has been removed, the led 7 L4 keeps lighted. Resetting is performed by pressing the push buttons 6 P1, P2 and P3 simultaneously.

By pressing the push buttons 6 P1 and P2 simultaneously, the calibration state can be reached.

Adjustment of the clock: in that state it is possible to adjust the inner clockwise of the device; the access to the state is allowed just if the burner electric valve is OFF. The adjustment is to be carried out by pressing the push buttons 6 P1 and P3 simultaneously, the display 5 shows the date and the hour stored. The changed in the clock is to be carried out through the push buttons 6 P1 and P2: in particular, by means of the push button P1 the slider can be shifted below the quantity to be changed; by means of the push button 6 P2, the quantity pointed out the slider is caused to go forward by one unit. Through the push button 6 P3 the display advancement is obtained and the device goes out of the state.

Distribution of consumptions: in that state it is possible to know the total fuel consumption at a particular date set forth in advance. The consumption is of the progressive type (from the beginning of the season) and it refers to the midnight of the day selected or to the present hour if the day selected is that in progress. The access to the state is to be carried out by pressing the push buttons 6 P2 and P3 simultaneously. A mask is visualized in which the actual date is reported. By means of the push buttons 6 it is also possible to visualize consumptions relating to a preselected date; in particular, by means of the push button 6 P1 the slider is shifted below the date so pointing out the quantity to be changed; by means of the push button 6 P2 the quantity pointed out by the slider is caused to advance by one unit. Through the push button 6 P3 the visuallization is obtained of consumption referred to the date selected. By pressing another time the push button 6 P3, the diplay 5 is caused to advance and the device goes out of the state.

Calibration: in the calibration state, it is possible to perform the starting of the device storing the operational quantities.

In order to have access to the calibration state, it is necessary to press the push buttons 6 P1 and P2 simultaneously: the display 5 shows the functions of the single push buttons. The calibration state is signaled by the led 7 L5.

Through the push buttons 6 P1 and P2, a pulse is transmitted to the strap 9 for a rotation whose duration is equal to a gain, respectively in the clockwise and in the anticlockwise sense; during the pressing of such push buttons 6, the leds 7 L1 and L3 respectively light. The lighting of the leds 7 L1 and L4 (positioned respectively above the trimmers 8 T1 and T4) points out the trimmers 8 on which it is necessary to act for storing the values of air and gas oil flowrates.

Through the push button 6 P3 the advancement of the display 5 is obtained as well as the going out of that state.

This invention has been disclosed with specific reference to some preferred embodiments of the same, but it is to be understood that modifications and/or changes can be introduced in the same by those who are skilled in the art without departing from the spirit and scope of the invention for which a priority right is claimed.

Claims

1. A device for controlling the fuel/comburant ratio in heat generators, in particular for civil plants, said device being characterized in that it comprises a first fuel flowrate sensor, which is sensitive to the mass flowrate and is capable of transducing the presence/absence of network at the terminals of the fuel flowrate control means into an ON/OFF electric signal, a second comburant flowrate sensor, which is sensitive to the mass flowrate, a transduction, control and actuation electronic member, which is capable of determining the operation of the device on the basis of the values set forth at the starting step, and on the basis of signals arriving from the two sensors, and a motorized control means which, following a command of an electric pulse sent by said electronic member, opens or closes the opening for the passage of comburant air so as to keep the value of the fuel/comburant ratio constant.

2. A device according to claim 1, characterized in that said transduction, control and actuation electronic member comprises at least a display, a plurality of precision adjustment members, a plurality of push buttons, a plurality of light indicators, at least two analogue inputs respectively for the signal relating to the comburant flowrate and to the fuel flowrate, at least two digital inputs respectively for the signal of the boiler thermostat and the burner electric valve, and at least four digital outputs respectively for supplying an air and gas oil probe, for supplying a gas oil flowrate probe, for the anticlockwise rotation of the motorized means and for the clockwise rotation of the same.

3. A device according to claims 1 or 2, characterized in that said electronic member is provided with an asynchronous signal gate for connection to a processor.

4. A device according to claims 2 or 3, characterized in that said electronic member is provided with two further analogue inputs respectively for the smoke temperature and for the outer temperature.

5. A device according to any one of the preceding claims 2-4, characterized in that said electronic member is provided with a pulse input for controlling the gas metres.

6. A device according to any one of the preceding claims 2-5, characterized in that said electronic member is provided with a display, five precision adjustment devices or trimmers, three push buttons, and five light indicators.

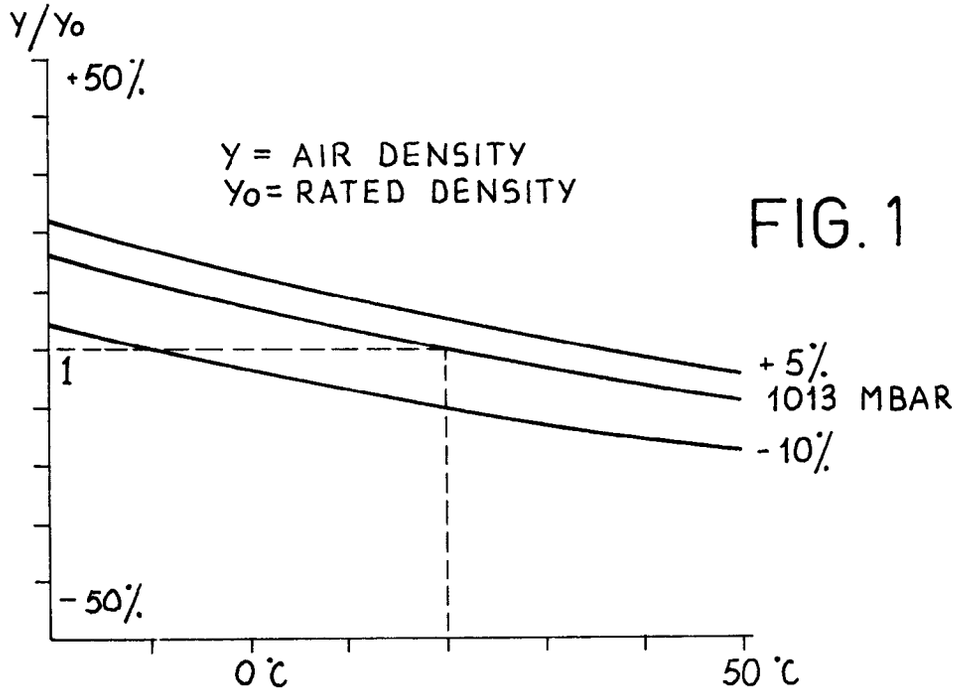

Y/Yo
+50%
Y = AIR DENSITY
Yo= RATED DENSITY
+5%
1013 MBAR
-10%
1
-50%
0 °C
50 °C

FIG. 1

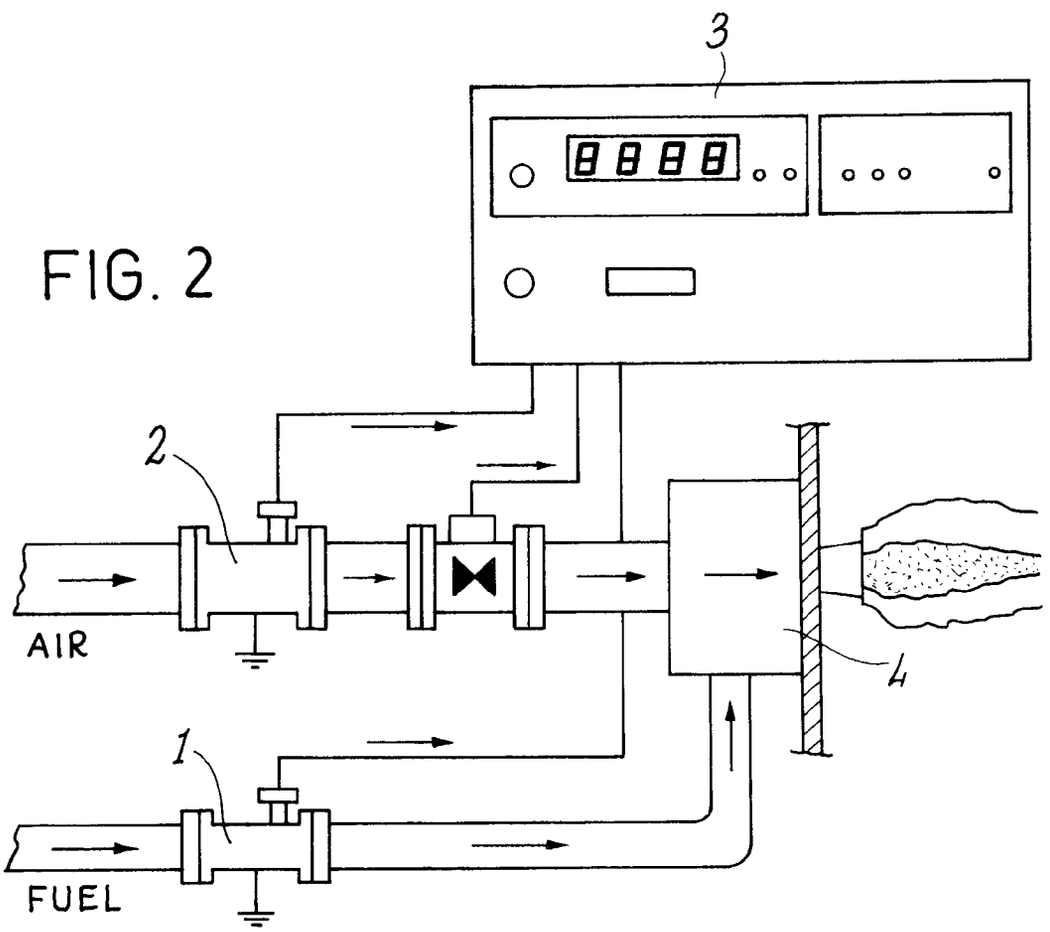
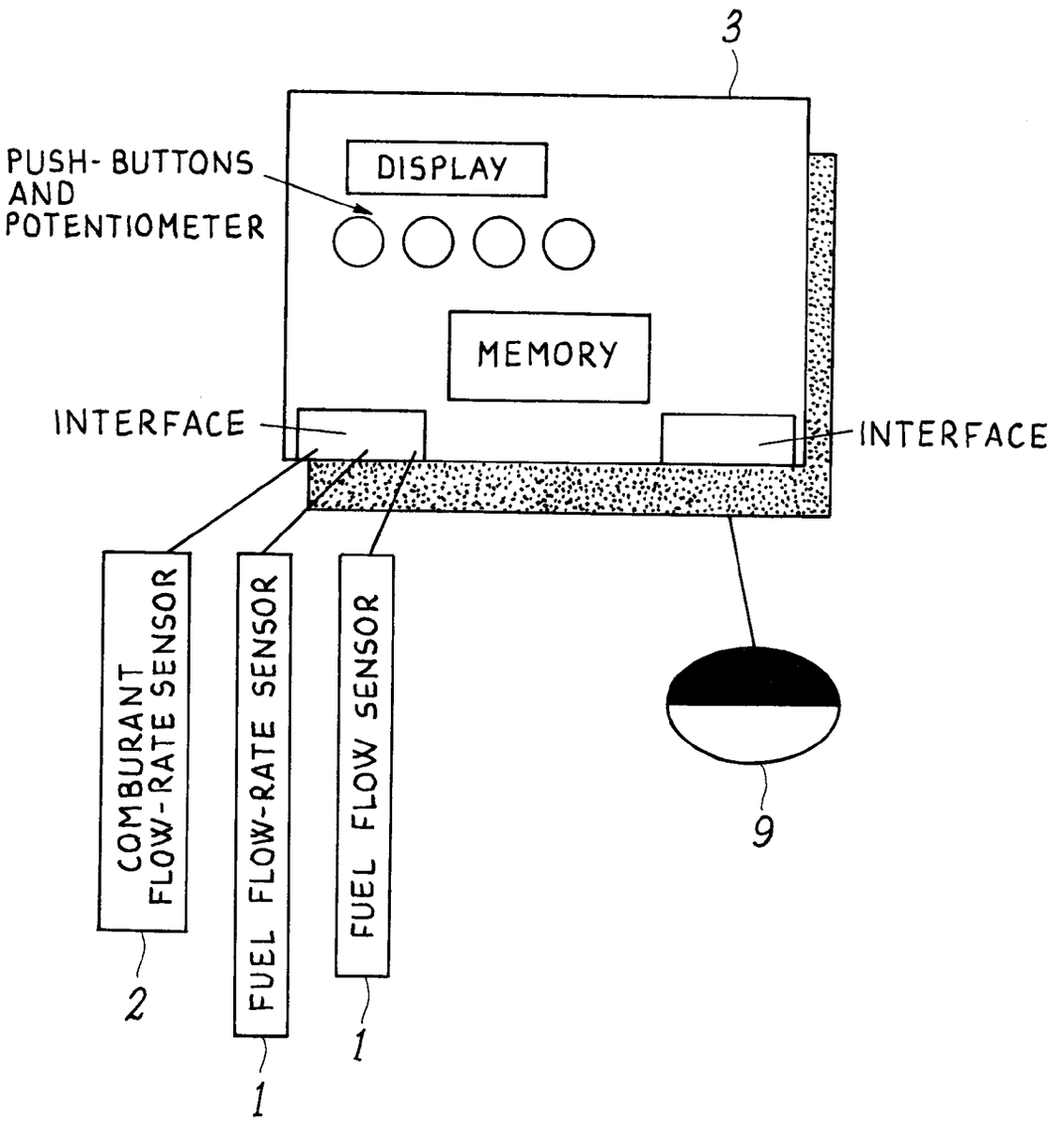

3
2
AIR
4
1
FUEL

FIG. 2

FIG. 3


3
PUSH- BUTTONS AND POTENTIOMETER
DISPLAY
MEMORY
INTERFACE
INTERFACE
COMBURANT FLOW-RATE SENSOR
FUEL FLOW-RATE SENSOR
FUEL FLOW SENSOR
2
1
1
9

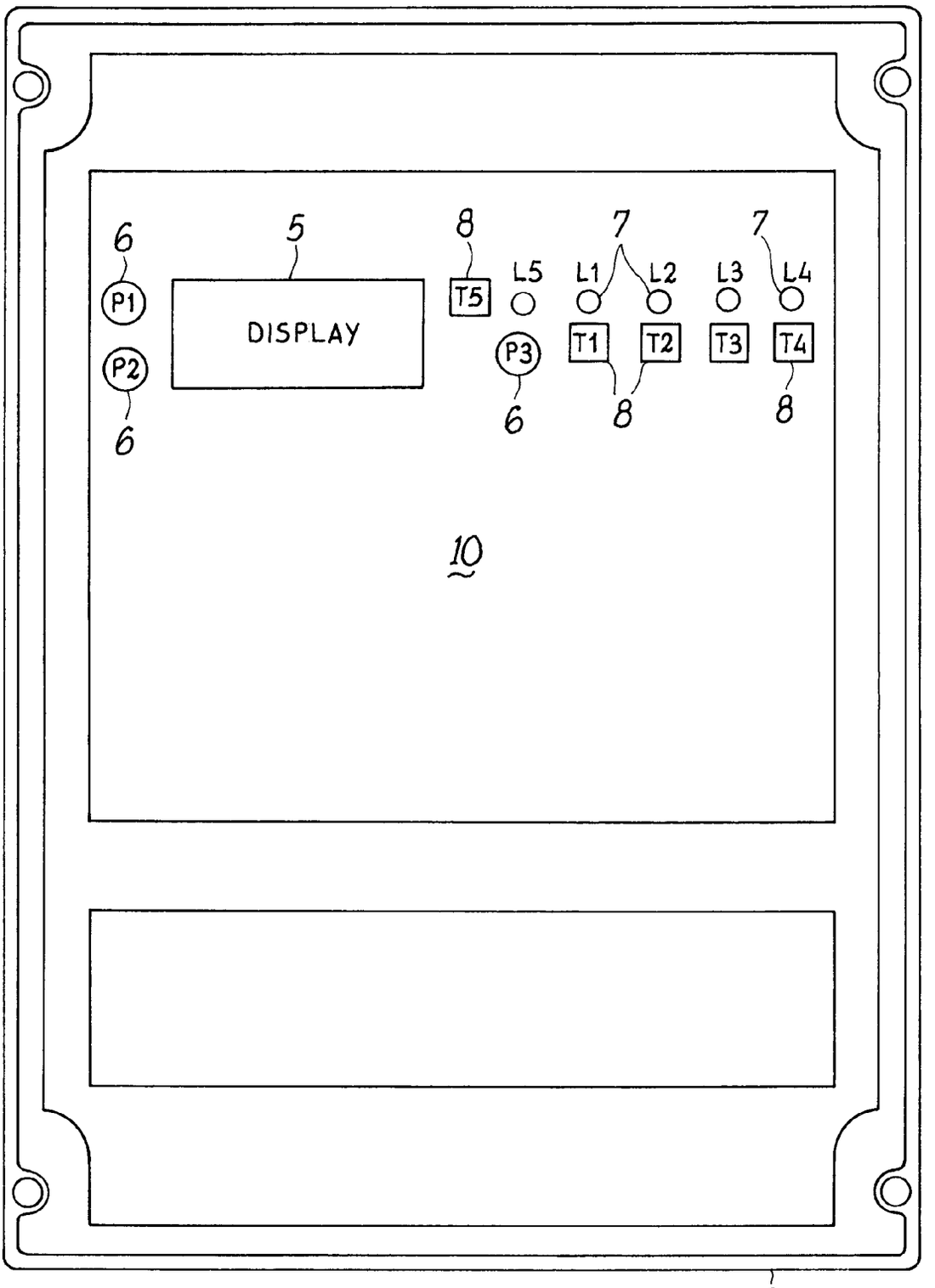


FIG. 4