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(54) **Control system for boilers**

Regelanlage für Kessel

Système de commande pour chaudières

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- **PATENT ABSTRACTS OF JAPAN vol. 015, no. 212 (M-1118), 30 May 1991 (1991-05-30) & JP 03 059315 A (YAMATAKE HONEYWELL CO LTD), 14 March 1991 (1991-03-14)**

EP 1 130 320 B1

Description

[0001] The system for the combined adjustment of air and gas for the control of the combustion and for an optimum efficiency at variable thermal loads in gas-fired boilers can be used on a wide range of boilers, thanks to some simplifications compared with the systems previously adopted. A combined gas-air control system according to the preamble of claim 1 is known from document EP-A-0 909 922.

1. Description

a) Complete Control

[0002] The main components of this control (fig. 1) are the following:

- Sensor for detection of water temperature S 1 (40).
- Potentiometer for setting the required temperature P1 (PTS sanitary temperature, PTR ambient heating).
- Fan (FAN)(36) whose speed is controlled by the mP-based control boar
- Differential analogue pressure switch (P.A.D.)(39) for the control of the vacuum in the combustion chamber.
- Gas modulator (MOD.)(41) controlled by the mP-based control board.
- Safety thermostat placed on the burner.

[0003] At the starting of the boiler, a control and adaptation cycle of the fan system, air sensor and flue-gas exhaust is carried out.
The operations performed are the following:

- The signal value generated by P.A.D. is checked. Such signal shall not exceed a fixed value. This operation assures that there is no upwind or a possible failure in the sensor/electronic system.
- In case the above check is satisfactory, the fan is started. The P.A.D. signal shall be greater than the above value plus a predetermined constant in order to assure the correct presence of vacuum in combustion chambers and the adaptation of the fan speed to the flue-gas exhausting system.
- Should this check also give satisfactory results, the burner is started
- During the operation, the underpressure in the combustion chamber is constantly monitored. If the vacuum value decreases under a pre-determined limit, the burner is turned off.

[0004] According to the plan in fig. 2, the required temperature is selected by means of a potentiometer P1 and is compared in the circuit PID A with the temperature detected by sensor S1. As a function of the difference between these values, the fan speed is calculated in order to achieve the required capacity. The fan speed is controlled by means of an adjustment system PID B to assure the steadiness of the required speed using as feedback signal the vacuum existing in the combustion chamber sensed by the analogue pressure switch P.A.D..

[0005] As a function of this vacuum the control originates the current value to be sent to the modulator so that a constant and optimum air-gas ratio is achieved. This assures the combustion with emission values within the required limits while maintaining an optimum efficiency at any thermal load.

[0006] The addition of a thermostat on the burner assures that the boiler is always operating within the required emission limits and in full safety. Actually the burner, as a function of its temperature, can stop the flame in case of an abnormal temperature rise due to a failure on the air or gas control system.

[0007] Such thermostat is placed electrically in series to the already existing limit thermostat. An intervention of this thermostat then places the boiler in a status of involatile shutdown.

[0008] Fig. 2 also shows the block A.C.F. that checks the presence of the flame and assures the safety functions by acting on the gas valve operating devices.

[0009] Fig. 3 shows the functional diagram of such system.

[0010] In this diagram T (PTS) represents the value for sanitary (or ambient heating) temperature required and determined by potentiometer P1. T (SS) represents the value of the water temperature detected by sensor S1. These values are compared in the sum block A1 and the result, error e(T), is applied to a control system PID represented by blocks Kp e(T), Ki Int[e(T)], Kd d[e(T)]e A2 in order to obtain the value V(H) representing the value of the required vacuum in the combustion chamber of the thermal load.

[0011] This value is compared in the sum block A4 with the feedback value Vc(H) originated by P.A.D. corresponding to the value of vacuum actually created by the fan. The result, error e(H), is applied to a control system PID, represented by blocks Kp e(H), Ki Int[e(T)], Kd d[e (T)]dt and to block V(F)=f[e(H)] in order to obtain VF, representing the required fan speed needed by the fan to produce the required vacuum in the combustion chamber.

[0012] The feedback value Vc(H) originated by P.A.D. is also used as input of the block T generating I(mod), the modulator current value, according to a predetermined curve correlating Vc(mod) to I(mod) in order to maintain the ratio air (produced by the fan at a speed VF) and gas (produced by the modulator with a current I(mod) and to grant an optimum combustion while maintaining

a steady thermal efficiency by varying loading conditions. The current of value I(mod) applied to the modulator of the gas valve produces the actual pressure P (gas) in the combustion chamber.

[0013] In case of burner overheating due to bad combustion with out-of-standard emissions, the burner thermostat (THERM BURN) turns on and provides to switch-off the burner thus bringing the boiler to safety shutdown

b) Simplified control

[0014] The main components of this control, as represented in fig. 4, are:

- Sensor for detection of water temperature S 1 (40).
- Potentiometer for setting the required temperature P1 (PTS sanitary temperature, PTR ambient heating).
- Fan (FAN)(36) whose speed is controlled by the mP-based control board
- Minimum differential pressure switch (P D.)(39) for the control of the vacuum in the combustion chamber.
- Gas modulator (MOD.)(41) controlled by the mP-based control board.
- Safety thermostat placed on the burner.

[0015] According to the plan of Fig. 5, the required temperature is selected by means of a potentiometer P1 and is compared in the circuit PID A with the temperature detected by sensor S1. As a function of the difference between these values, the fan speed is calculated in order to obtain a steady air-gas ratio and to assure the combustion with emission values within the required limits, while maintaining an optimum efficiency at any thermal load

[0016] At every starting of the boiler, a control cycle of the fan system, air sensor and flue-gas exhaust is carried out.

[0017] The value of the signal generated by P.D. is checked. Such signal shall not give its consent in the absence of fan operation; as a consequence there is no upwind or a possible failure in the pressure switch/electronic system.

[0018] Upon demand of heat, the fan is started at the maximum speed in order to assure the connection of the differential pressure switch and, therefore, to check the correct operation of the fan/flue-gas-exhausting system.

[0019] During the operation, the underpression in the combustion chamber is constantly monitored. If the vacuum value decreases under a pre-determined limit, the pressure switch P.D. gives no longer its consent and, therefore, the boiler is turned off.

[0020] The addition of a thermostat on the burner assures that the boiler is always operating within the required emission limits and in full safety. Actually the burner, as a function of its temperature, can stop the flame in case of an abnormal temperature rise due to a failure on the air or gas control system

[0021] Such thermostat is placed electrically in series to the already existing limit thermostat. An intervention of this thermostat, therefore, places the boiler in a status of involatile shutdown.

[0022] Fig. 5 also shows the block A.C.F. that check the presence of the flame and assures the safety functions by acting on the gas valve operating devices.

[0023] Fig. 6 shows the functional diagram of such system.

[0024] In this diagram T(PTS) represents the value of sanitary (or ambient heating) temperature required and determined by potentiometer P1. T(SS) represents the water temperature value detected by sensor S1. These values are compared in the sum block A1 and the result, error e(T), is applied to a control system PID in order to obtain the value V(FAN) representing the value of the fan speed as a function of the demand of the thermal load.

[0025] This value (V(Fan)) applied to the fan (block V (F)=f[e(H)]) produces the actual speed VF.

[0026] The Value V(Fan) is also used as input of the block T that produces I(Mod), the modulator current value, according to a pre-determined curve correlating V (Fan) to I(mod) in order to maintain the air-gas ratio produced by the modulator with current I(mod) and to grant an optimum combustion while maintaining a steady thermal efficiency by varying loading conditions. The current value I(mod) applied to the gas valve modulator produces the actual pressure P(gas) in the combustion chamber.

Claims

1. Air/gas adjusting system for boilers, comprising:

a combustion chamber, having a burner (BURNER);
a sensor (40, S1) for detecting water temperature;
a potentiometer (P1) for setting a required temperature;
a fan (36, FAN), a speed whereof is controlled by a
microprocessor-based control board;
a differential analogue pressure switch (PAD), providing a signal correlated to the underpressure in said combustion chamber;
a gas modulator (41, MOD), controller by said microprocessor-based control board;
first control means (PIDA, PIDB; PID A), for controlling said speed of said fan (36, FAN) based on said underpressure signal, wherein said first control means (PIDA, PIDB; PID A) includes:

a first PID controller (PIDA) for calculating a required fan speed as a function of a difference between said required temperature selected by said potentiometer (P1) and

said water temperature detected by said sensor (S1) ;
and a second PID controller (PIDB) for controlling said fan speed as a function of said required fan speed and of said underpressure signal;

second control means (AIR/GAS RATIO) generating a current as a function of said signal for controlling a said gas modulator so that a constant and optimum air-gas ratio is achieved;

characterised in that it comprises:

first enabling means, configured for selectively enabling starting said fan (36, FAN) conditional on said underpressure signal being smaller than a fixed value before starting said fan, for selectively enabling said burner (BURNER), conditional on said signal being greater than said fixed value plus a predetermined constant after starting said fan (36, FAN), and for disabling said burner (BURNER) if, in operation, a vacuum level decreases under a predetermined limit;
a thermostat (BURN THERM), arranged on said burner, and second enabling means (BURN THERM SAFETY CONTROL; SAFETY CONTROL), coupled to said thermostat (BURN THERM) and to said burner (BURNER), for selectively enabling said burner (BURNER) based on the temperature measurement of said thermostat (BURN THERM);
and a further limit thermostat, arranged in series to said thermostat (BURN THERM) of said safety device.

Patentansprüche

1. Luft/Gasreguliersystem für Kessel, das umfasst:

eine Brennkammer, die einen Brenner (BURNER) aufweist;
einen Sensor (40, S1) zum Erfassen von Wassertemperatur;
ein Potentiometer (P1) zum Einstellen einer erforderlichen Temperatur;
ein Gebläse (36, FAN), dessen Geschwindigkeit durch ein Steuerpult auf Mikroprozessorbasis gesteuert wird;
einen Differenz-Analog-Druckschalter (PAD), der ein mit dem Unterdruck in der Brennkammer korrelierendes Signal bereitstellt;
einen Gas-Modulator (41, MOD), der durch das Steuerpult auf Mikroprozessorbasis gesteuert wird;
eine erste Steuereinrichtung (PIDA, PIDB; PID A) zum Steuern der Geschwindigkeit des Gebläses (36, FAN) auf Basis des Unterdruck-Signals, wobei die erste Steuereinrichtung (PIDA, PIDB; PID A) enthält:

eine erste PID-Steuereinheit (PIDA) zum Berechnen einer erforderlichen Gebläsegeschwindigkeit als Funktion einer Differenz zwischen der durch das Potentiometer (P1) ausgewählten erforderlichen Temperatur und der durch den Sensor (S1) erfassten Wassertemperatur;
eine zweite PID-Steuereinheit (PIDB) zum Steuern der Gebläsegeschwindigkeit als Funktion der erforderlichen Gebläsegeschwindigkeit und des Unterdruck-Signals;
eine zweite Steuereinrichtung (AIR/GAS RATIO), die einen Strom als Funktion des Signals erzeugt, um den Gas-Modulator so zu steuern, dass ein konstantes und optimales Luft-Gas-Verhältnis erreicht wird,

dadurch gekennzeichnet, dass es umfasst:

eine erste Aktivierungseinrichtung, die so konfiguriert ist, dass sie selektiv Starten des Gebläses (36, FAN) unter der Bedingung aktiviert, dass das Unterdruck-Signal unter einem festgelegten Wert liegt, bevor das Gebläse gestartet wird, selektiv den Brenner (BURNER) unter der Bedingung aktiviert, dass das Signal über dem festgelegten Wert plus einer vorgegebenen Konstante nach Starten des Gebläses (36, FAN) liegt, und das den Brenner (BURNER) deaktiviert, wenn in Funktion ein Vakuumpegel unter eine vorgegebene Grenze fällt;
einen Thermostat (BURN THERM), der an dem Brenner angeordnet ist, und eine zweite Aktivierungseinrichtung (BURN THERM SAFETY CONTROL; SAFETY CONTROL), die mit dem Thermostat (BURN THERM) und dem Brenner (BURNER) gekoppelt ist, um den Brenner (BURNER) auf Basis der Temperaturmessung des Thermostats (BURN THERM) selektiv zu aktivieren; und
einen weiteren Grenz-Thermostat, der in Reihe mit dem Thermostat (BURN THERM) der Sicherheitsvorrichtung angeordnet ist.

Revendications

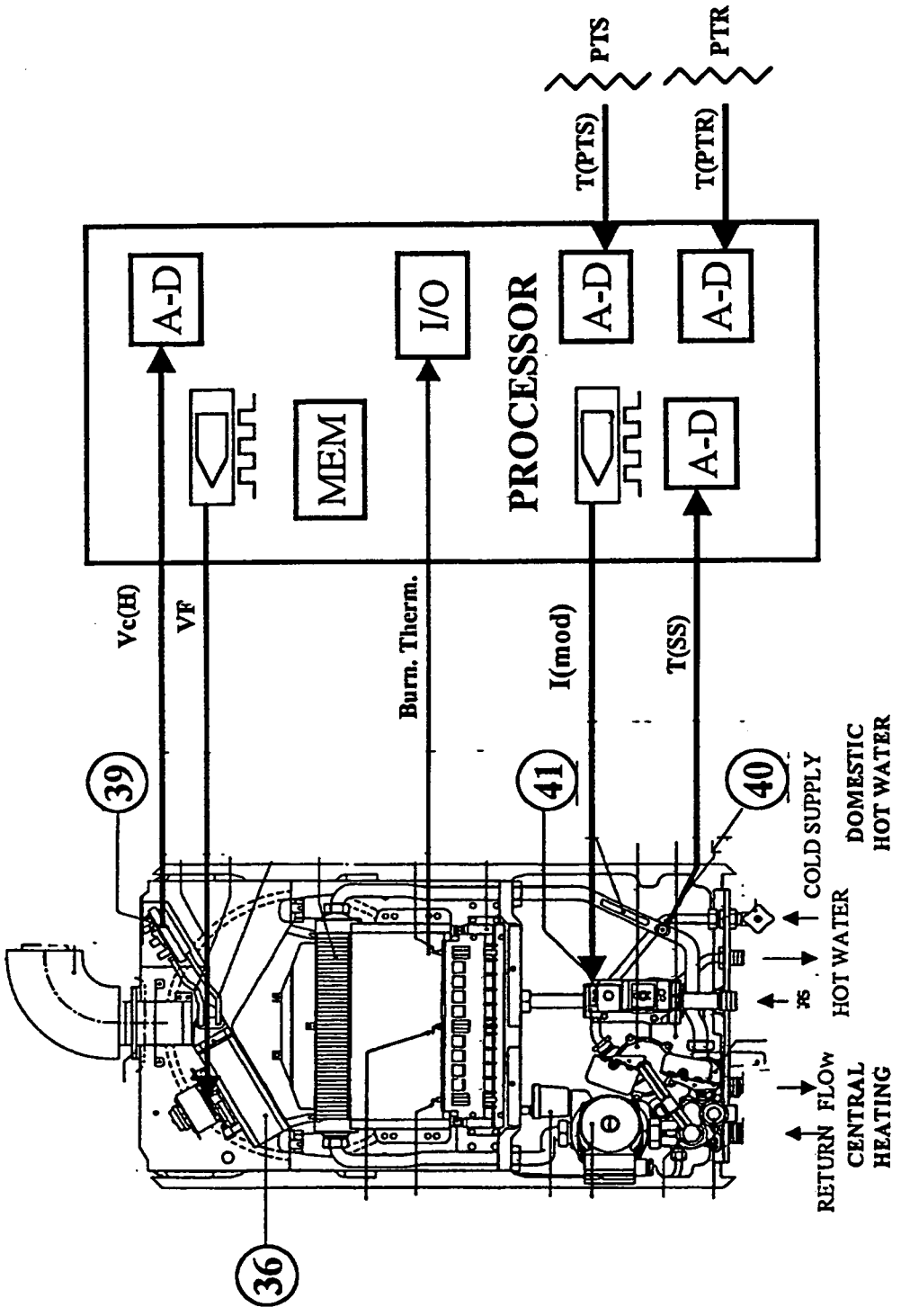
1. Système de réglage air / gaz de chaudières, comprenant : une chambre de combustion, possédant un brûleur (BURNER) ;
un capteur (40, S1) pour capter la température de l'eau ;
un potentiomètre (P1) pour fixer une température requise ;

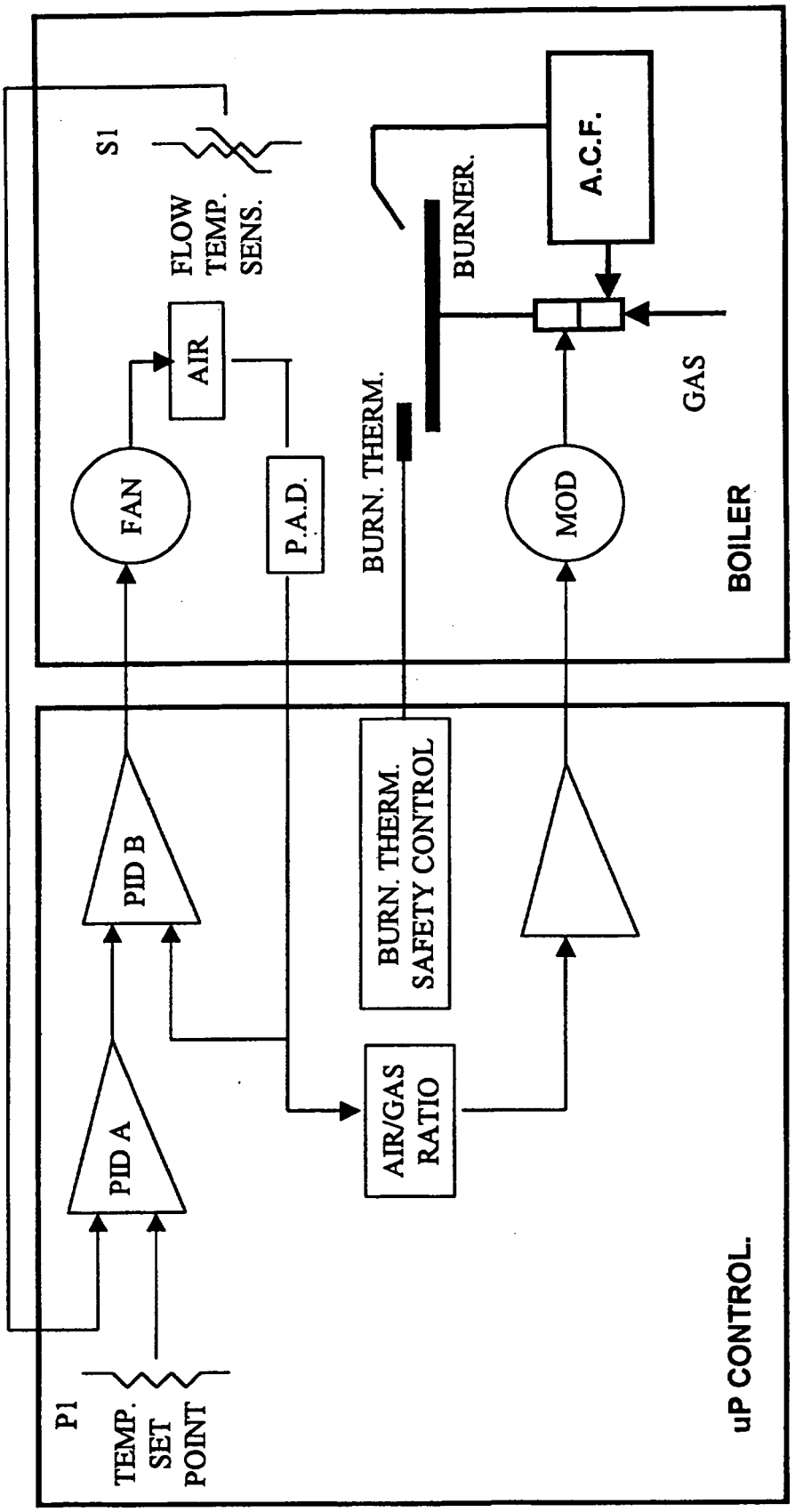
un ventilateur (36, FAN), dont la vitesse est commandée par une carte de commande à base de microprocesseur ;
un pressostat analogique différentiel (PAD), fournissant un signal corrélé à la dépression dans ladite chambre de combustion ;
un modulateur de gaz (41, MOD), commandé par ladite carte de commande à base de microprocesseur ;
des premiers moyens de commande (PIDA, PIDB ; PID A), pour commander ladite vitesse dudit ventilateur (36, FAN) sur la base dudit signal de dépression, dans lequel lesdits premiers moyens de commande (PIDA, PIDB ; PID A) comprennent :

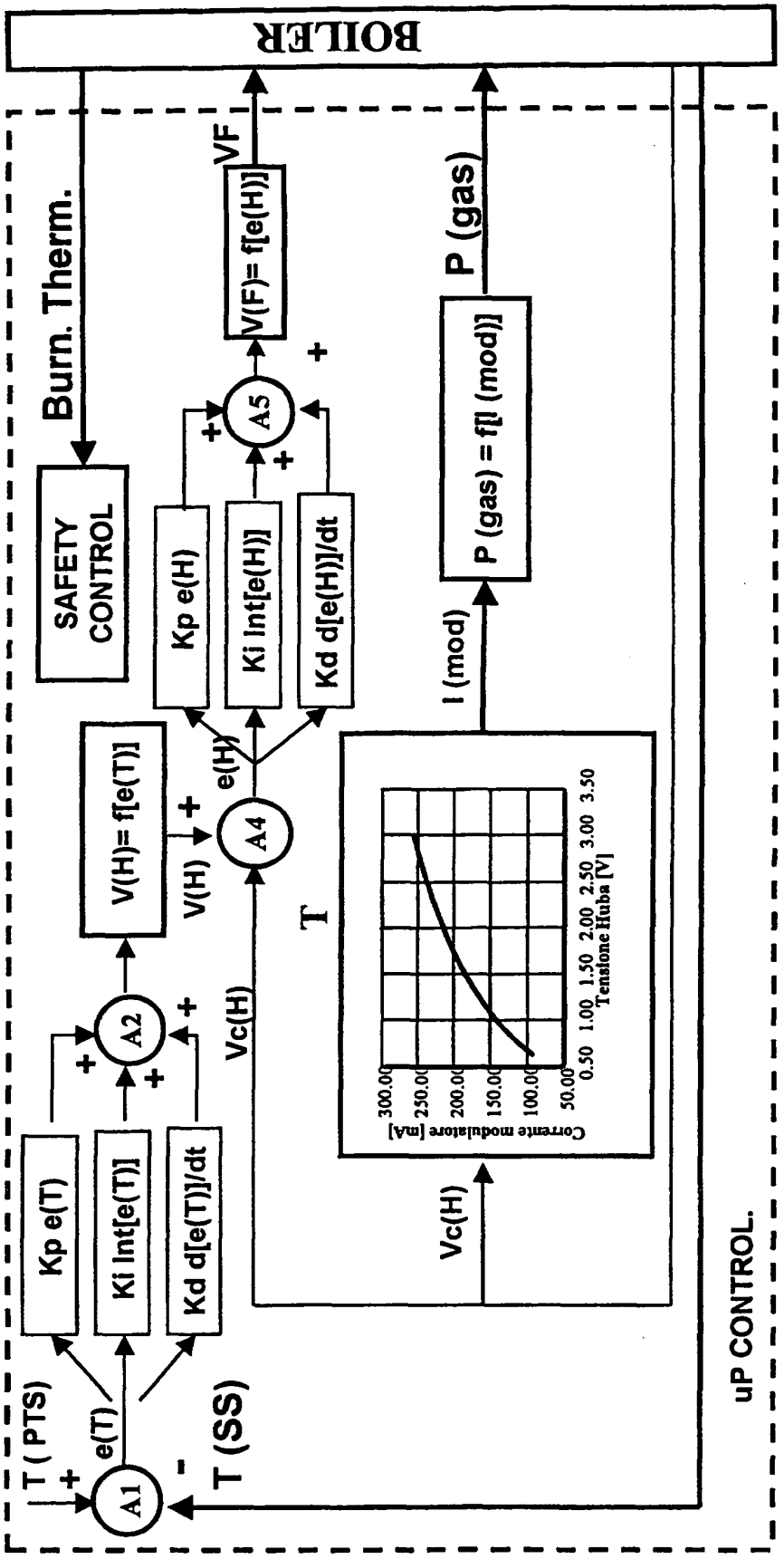
un premier contrôleur PID (PIDA) pour calculer une vitesse de ventilateur requise en fonction d'une différence entre ladite température requise sélectionnée par ledit potentiomètre (P1) et ladite température de l'eau captée par ledit capteur (S1) ;
et un second contrôleur PID (PIDB) pour contrôler ladite vitesse du ventilateur en fonction de ladite vitesse du ventilateur requise et de ledit signal de dépression ;
des seconds moyens de commande (AIR / GAS RATIO) pour générer un courant en fonction dudit signal pour commander un dit modulateur de gaz de façon à obtenir un rapport air - gaz optimum ;

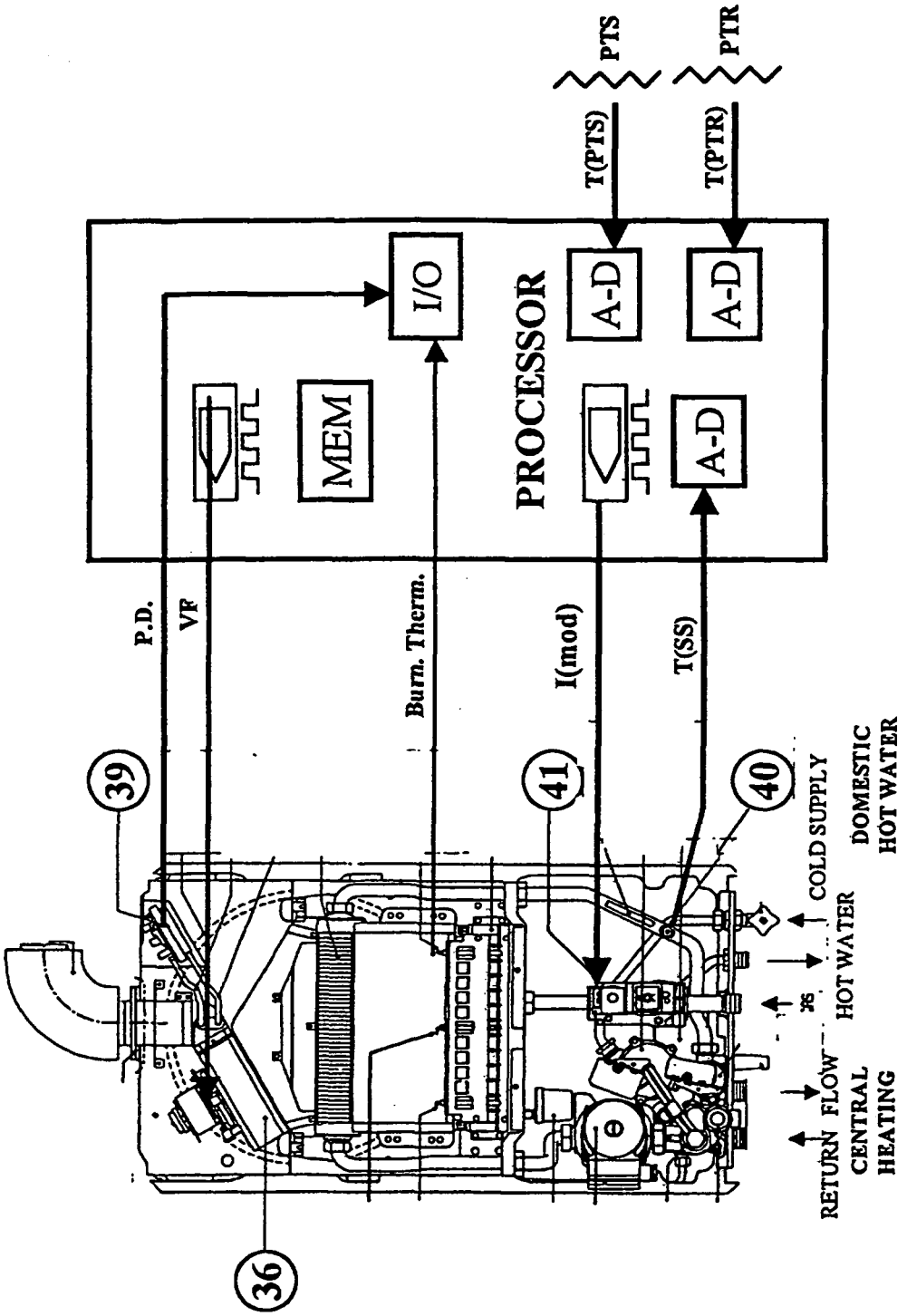
caractérisé en ce qu'il comprend :

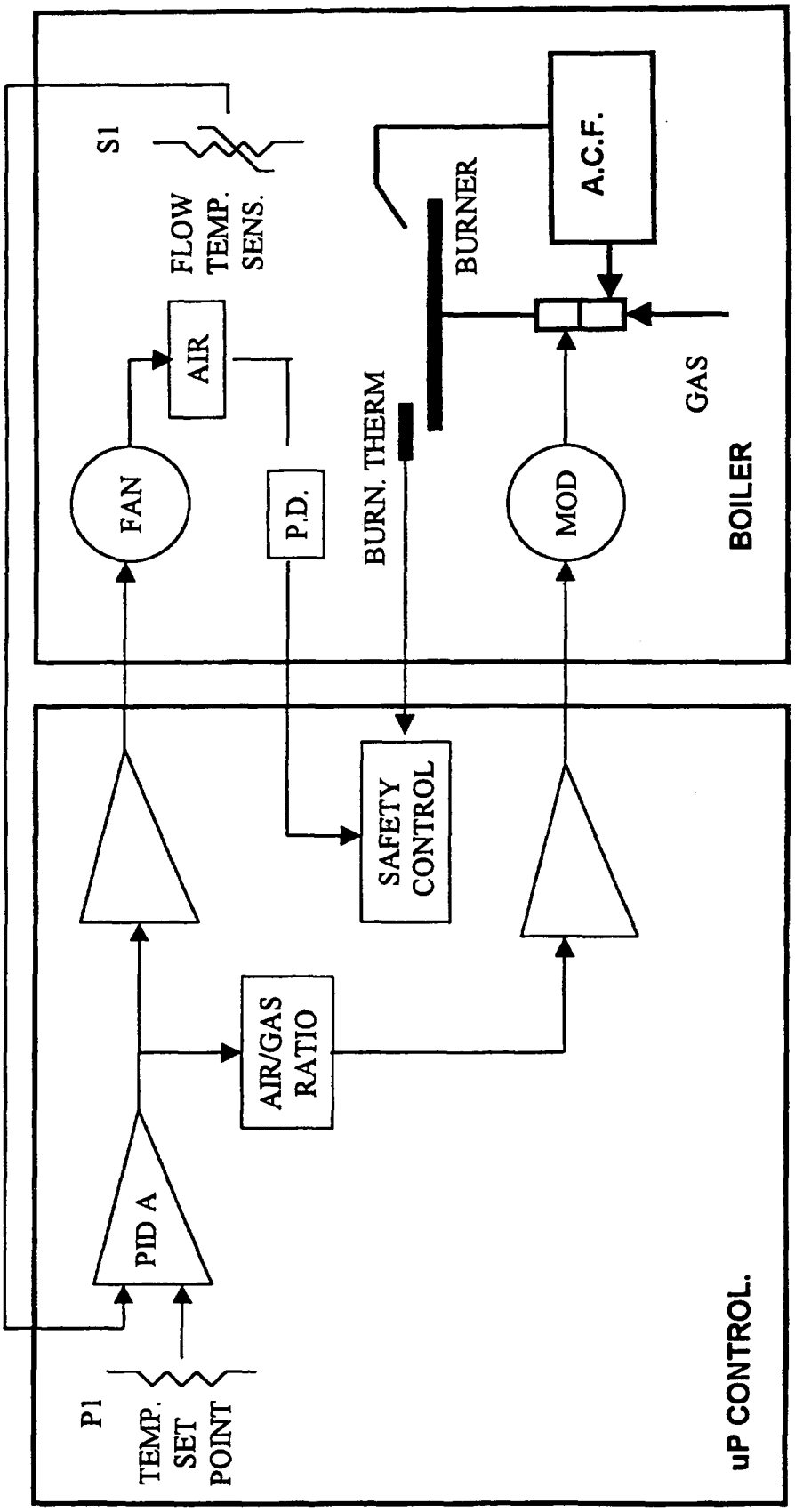
des premiers moyens d'activation, configurés pour activer de manière sélective le démarrage dudit ventilateur (36, FAN) à condition que ledit signal de dépression soit plus petit qu'une valeur fixe avant le démarrage dudit ventilateur, pour activer de manière sélective ledit brûleur (BURNER), à condition que ledit signal soit plus grand que ladite valeur fixée plus une constante prédéterminée après le démarrage dudit ventilateur (36, FAN), et pour désactiver ledit brûleur (BURNER) si, en fonctionnement, le niveau de dépression diminue sous une limite prédéterminée ;
un thermostat (BURN THERM), disposé sur ledit brûleur, et des seconds moyens d'activation (BURN THERM SAFETY CONTROL ; SAFETY CONTROL), reliés audit thermostat (BURN THERM) et audit brûleur (BURNER), pour activer de manière sélective ledit brûleur (BURNER), sur la base de la mesure de la température dudit thermostat (BURN THERM) ;
et un autre thermostat de limite, disposé en série avec ledit thermostat (BURN THERM) dudit dispositif de sécurité.

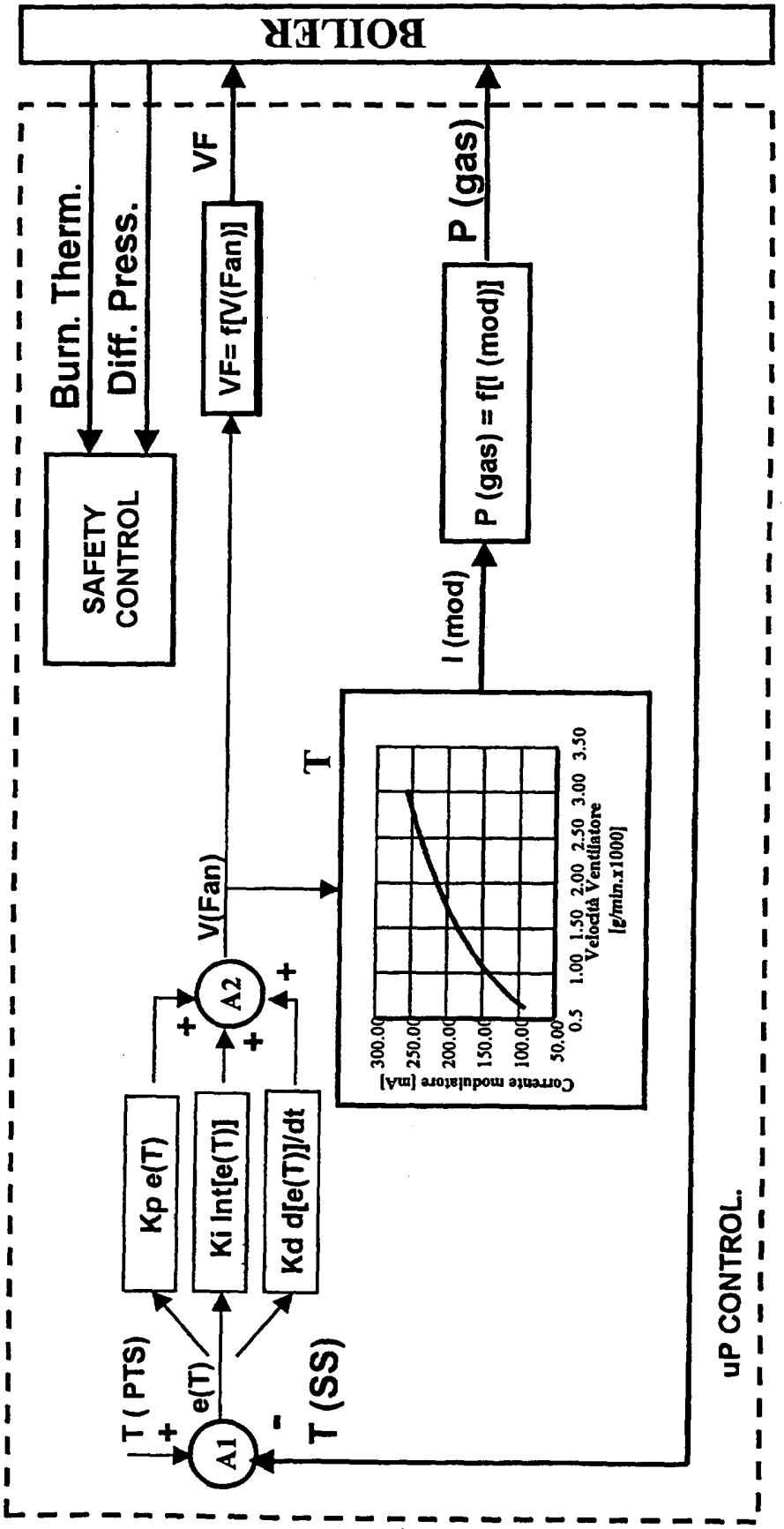

PTS
PTR
T(PTS)
T(PTR)
A-D
A-D
A-D
A-D
I/O
MEM
PROCESSOR
Vc(H)
VF
Burn. Therm.
I(mod)
T(SS)
39
41
40
36
COLD SUPPLY
DOMESTIC HOT WATER
HOT WATER
CENTRAL HEATING FLOW
RETURN


S1
FLOW TEMP. SENS.
A.C.F.
BURNER.
AIR
FAN
P.A.D.
BURN. THERM.
MOD
GAS
BOILER
PID B
BURN. THERM. SAFETY CONTROL
PID A
AIR/GAS RATIO
P1
TEMP. SET POINT
uP CONTROL.


BOILER
Burn. Therm.
SAFETY CONTROL
V(H)= f[e(T)]
V(H)
A4
e(H)
Kp e(H)
Ki Int[e(H)]
Kd d[e(H)]/dt
A5
V(F)= f[e(H)]
VF
P (gas)
P (gas) = f[I (mod)]
I (mod)
T
Vc(H)
Corrente modulatore [mA]
Tensione Hiuba [V]
A2
Kp e(T)
Ki Int[e(T)]
Kd d[e(T)]/dt
e(T)
A1
T (PTS)
T (SS)
uP CONTROL.


PTS
PTR
T(PTS)
T(PTR)
I/O
PROCESSOR
A-D
A-D
A-D
MEM
P.D.
VF
Burn. Therm.
I(mod)
T(SS)
39
41
40
36
COLD SUPPLY
HOT WATER
DOMESTIC HOT WATER
RETURN FLOW
CENTRAL HEATING


S1
FLOW TEMP. SENS.
A.C.F.
BURNER
AIR
FAN
P.D.
BURN. THERM
MOD
GAS
BOILER
SAFETY CONTROL
AIR/GAS RATIO
PID A
P1
TEMP. SET POINT
uP CONTROL.


BOILER
Burn. Therm.
Diff. Press.
VF
P (gas)
VF= f[V(Fan)]
P (gas) = f[I (mod)]
SAFETY CONTROL
I (mod)
T
V(Fan)
A2
A1
Kp e(T)
Ki Int[e(T)]
Kd d[e(T)]/dt
T (PTS)
e(T)
T (SS)
uP CONTROL.
Corrente modulatore [mA]
300.00
250.00
200.00
150.00
100.00
50.00
0.5
1.00
1.50
2.00
2.50
3.00
3.50
Velocità Ventilatore [g/min.x1000]