PCT

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F23N 5/08

A1

(11) International Publication Number: WO 91/15715

(43) International Publication Date: 17 October 1991 (17.10.91)

(21) International Application Number: PCT/GB91/00468

(22) International Filing Date: 27 March 1991 (27.03.91)

(30) Priority data:
9007448.5 3 April 1990 (03.04.90) GB

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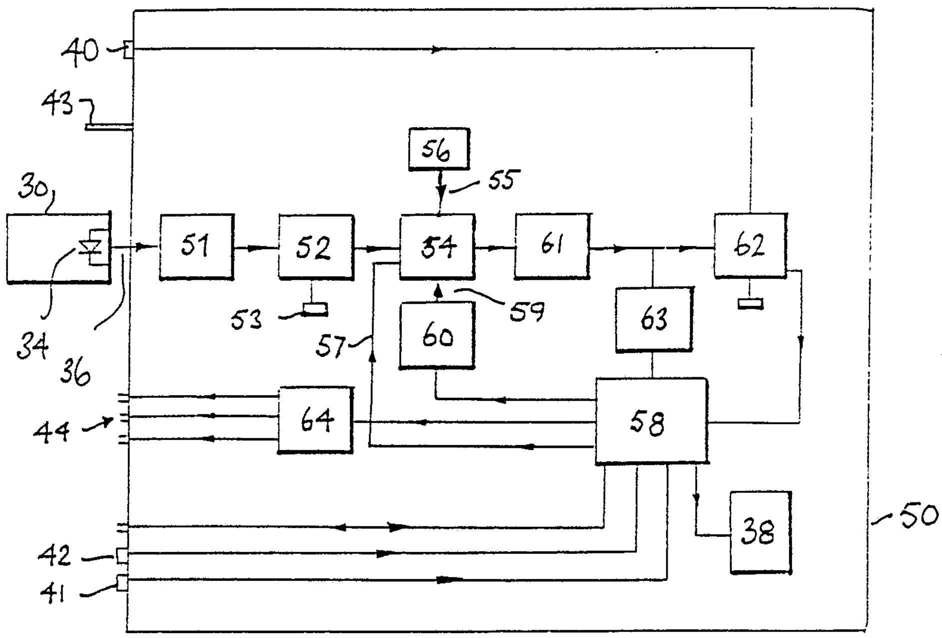
(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

**Published**
*With international search report.*

(54) Title: BURNER CONTROL




**(57) Abstract**

Monitoring of a burner-generated flame in a flame zone is achieved by watching for changes in amplitude of radiation leaving the flame zone using an opto-electric transducer (34) and a processing circuit (50) which is tuned to a flicker frequency pass band targeted on the looked-for flame. A tunable band-pass switched capacitor filter (54) feeding into a threshold detector (62) via an AC/DC converter (61) is preferred.

# BURNER CONTROL

## Technical Field

This invention relates generally to the control of fuel burners and in particular to the monitoring of individual fuel burners in an array of such burners including, for example, the monitoring of the performance of a start-up burner. The invention will find use in the monitoring of oil, gas and solid fuel burners but is expected to have particular application in a pulverised coal environment.

In large fuel-burning installations (e.g. power station boilers) a plurality of burners are provided which operate in concert to generate the currently required thermal output. As the thermal output required increases, additional burners may need to be brought into operation and conversely, as the required thermal output decreases, burners may need to be taken out of operation. Starting-up a burner is an operation which requires proper sequencing of events and this is particularly so when a start-up flame using an easily ignitable start-up fuel (e.g. oil) is used to pre-heat the flame zone of a burner to receive a less readily combustible main fuel (e.g. pulverised coal or biomass).

The pre-heating stage requires a good control system which will reliably indicate when the start-up fuel is ignited and optionally also when the main fuel is burning efficiently.

Where there are few burners physically well-spaced-apart conventional techniques can be used for burner monitoring and these include visually observing the flame zone. However, where there are closely packed banks of burners whose flame zones merge, conventional techniques have failed to provide reliable control, leading, inter alia, to the possibilities of inefficient combustion of main fuel, waste of start-up fuel, risks of explosions and generation of excessive amounts of environmentally polluting waste gases.

This invention therefore seeks to provide a burner-monitoring system which will obviate at least some of the above-noted disadvantages.

Summary of the Invention

According to one aspect of the invention there is provided a method of monitoring a potential flame zone of a burner for the existence of a burner - generated flame of a required type, which method comprises directing radiation received from and through at least a part of said zone onto a photo-sensitive area of an opto-electric transducer device, feeding the output of the transducer device to circuit means adapted to generate an output signal which is related to the radiation falling on the sensitive area and determining from the magnitude of a parameter of the output signal whether there is or is not a flame of the required type in the flame zone, which method is characterised in that the circuit means includes a band-pass filter to eliminate the contributions of radiation having frequencies of amplitude variation (hereafter, for convenience, referred to as "flicker" frequencies) below or above the pass band, in that the pass band of the filter is set to that part of the frequency spectrum where the flicker frequency of a flame of the required type is detectable against background radiation passing through said zone (i.e. the radiation falling on the sensitive area when there is no burner-generated flame of the required type in the flame zone), and in that the output signal in the pass band is used to determine whether a flame of the required type is present in the monitored flame zone.

Preferably the centre frequency of the band-pass filter is tunable and an initial stage of the monitoring method involves setting said centre frequency on the basis of a determination of a difference between the output signal when a flame of the required type is and is not present in said zone. Normally the said centre frequency will be selected to correspond to the maximum amplitude of said difference signal.

Preferably the pass band of the filter excludes the mains frequency at its low frequency end and exceeds ten times the mains frequency at its high frequency end. The particular pass band selected will depend upon circumstances, but can be expected to lie somewhere in the range 70 to 90 Hz at the low frequency end and between 1 and 2 KHz at the high frequency end.

In practice we prefer to determine a first output signal level ($S_B$) in the form of a frequency spectrum relating to the background radiation passing through said zone, to determine a second output signal level ($S_{B+F}$) in the form of a further frequency spectrum relating to the background radiation passing through said zone and the radiation created by a flame in said zone and to create a difference signal ($S_D$) which is the difference between the signals $S_{B+F}$ and $S_B$ (i.e. $S_D = S_{B+F} - S_B$) and to use this difference as indicative of the flicker frequency signals actually arising in the flame zone and to tune the band pass filter so that it is centred on the frequency at which the peak amplitude of the difference signal ($S_D$) occurs. In this way the band pass filter is set for optimum targeted flame discrimination.

The range of flicker frequencies being monitored is desirably sub-divided into a substantial number (say 100 in a typical case) of sub-band memory locations and the frequency spectrum is stored as digital numbers (each say between 0 and 99) one in each sub-band memory location. For economy of memory requirements, the set of memory locations used to receive the discrete sub-bands of the first output signal level ($S_B$) can be used to store the sub-bands of the difference signal ($S_D$), so that the second output signal level ($S_{B+F}$) is used to modify the number stored in each memory location and is not separately stored as such.

A sighting tube leading directly towards the flame zone is conveniently used to direct radiation to the photo-sensitive area of the opto-electric transducer and preferably this tube includes lens means to focus the radiation from the flame zone onto the said area. A single convex lens (e.g. of 2.5 cm focal length and 22 mm diameter) has been found to be a suitable lens means for this application.

Detection can be undertaken at any suitable wavelength but operation in the infra-red to near-ultraviolet range is preferred.

The method of the invention is expected to find particular utility in the monitoring of the individual burners of a wall-fired pulverised fuel (p.f.) boiler where oil is used for the start-up (or light-up) burner. By means of the invention we have been able to determine whether one burner in a bank of 20 is ignited when all other 19 burners are operating and whether that one burner is operating satisfactorily on oil, oil and p.f. or just on p.f.. However, the invention is expected to find other applications in the monitoring of the performance of burners and its use with an oil/p.f. burner should be seen to be one example of possible uses and not as a limitation to use.

The opto-electric transducer is suitably a silicon-based device (e.g. a VACTEC VTB 5050 UV) and the processing of the output signal is conveniently effected using a micro-computer (e.g. an Intel 8032). The band-pass filtering is desirably arranged using a band-pass switched capacitor filter circuit.

In the case of the monitoring for the presence of a gas-fired flame, it is desirable to operate at the ultra violet end of the spectrum and in these circumstances it can be useful to use a gas discharge phototube as the opto-electric transducer.

Apparatus for carrying out the method of the invention which includes an opto-electric transducer and signal processing equipment to act on the electrical output of the transducer and generate a "flame-on" signal in the presence of a looked-for flame in a monitored flame zone, is characterised in that the signal processing equipment includes means to determine a flicker frequency which is sensitive to the presence or absence of the looked-for flame, a band-pass filter to receive the output of the transducer, a threshold device to receive the output of the band-pass filter and generate the "flame-on" signal and means to tune the band-pass filter to the determined flicker frequency. A particularly convenient circuit for processing the output signals from the transducer is a tunable band-pass switched capacitor filter feeding into an RMS converter.

Brief Description of the Drawings

The invention will now be further described by reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a modern pluri-burner boiler,

Figure 2 is the typical layout of a wall-fired boiler,

Figure 3 is an enlarged cross-section through a flame wall of the boiler of Figure 2,

Figures 4 and 4A are cross-section and end views, respectively, of a p.f. oil start-up burner for use in the flame wall of Figure 3,

Figures 5 and 6 are power spectral density graphs for oil flame flicker and p.f. flame flicker, respectively,

Figure 7 is a schematic view of flame-flicker detection equipment in accordance with this invention,

Figure 8 is a block circuit diagram of the electronic equipment for operating the equipment of Figure 7, and

Figures 9A to 9C are examples of frequency spectrum signals illustrating how the monitoring method of the invention is employed in a practical case.

Description of Preferred Embodiments

A typical layout of a modern boiler and the associated plants is shown in Figure 1.

The main fuel is coal, which is delivered from bunkers 1 to mills 2, where it is ground before being blown into a furnace 3 by a "primary" air stream as pulverised fuel (p.f.). The air required for combustion is blown by a forced draught fan 4 through an air-heater 5, where it is warmed by the flue gases which have passed through the boiler. The 80% or so of air which does not go to the mill 2 is introduced to the furnace through burners 10 as "secondary" air via a windbox 6.

After losing about 30% of the heat of combustion in the furnace by radiation to surrounding evaporator tubes, the flue gas passes over various stages of superheater 7, reheater 8 and economizer 9 surfaces, to which it loses another 50% by a combination of radiation and convection. Finally, a further 10% is transferred to the combustion air in the rotary regenerative air-heater 5 to be returned to the furnace. This small percentage is thus recycled, but about 10% is lost to the atmosphere through a chimney 11.

Before reaching the chimney 11, the flue gas is cleaned of particulate matter in an electrostatic precipitator 12 or a bag filter. Optionally, also, at least some of the sulphur dioxide is removed in a flue-gas desulphurization unit or scrubber. A fan 13 provides the suction to exhaust the furnace (which is usually run at just sub-atmospheric pressure) and draws the flue gas through the boiler, air-heater, precipitator and scrubber to bring it to the base of the chimney 11 at about atmospheric pressure and 100-200°C. The gas is then driven up the chimney by its own buoyancy.

There is a wide variety of possible boiler firing configurations. However, the wall- or corner-fired boilers are the two most commonly used boiler firing configurations for large industrial boilers although other boiler firing configurations can be found.

A wall-fired p.f. boiler with individual burners 10 is shown in Figure 2. The burners may be arranged on one wall of the furnace, on two opposite walls (opposed-firing) or less commonly, on all four walls.

A cross-section of the flames produced in a front wall-fired boiler is shown in Figure 3, the windbox again being shown at 6 and the burners' flames at 14. Each burner 10 is associated with a flame-sighting tube 15, only one of which is shown and this is drawn out of position for clarity.

A mechanical layout of a typical oil burner is shown in Figures 4 and 4A. The primary air and coal enter the combustion chamber through pipe 20 (the p.f. outlet pipe) which passes concentrically through a cylindrical secondary air register 21. There is a fixed degree of swirl given to the secondary air as it passes through the register 21 and into the burner by a number of peripherally spaced vanes

22. At the exit 23 of the p.f. outlet pipe 20 is fitted a coal spreader 24 which diverts the p.f. in a conical stream into the surrounding secondary air. The spreader 24 is supported on the end of a tube 25 which passes down the centre of the p.f. outlet pipe 20 and which also carries the barrel of the oil start-up burner 26, thus, the oil and p.f. burners are concentric.

When the burner is operating on oil (i.e. in its start-up mode) the flame is ignited (e.g. by a propane/electric torch which is sited alongside the oil burner barrel within the burner carrier tube).

The radiation from a flame varies in amplitude at all times. That is, it is momentarily changing from brighter to dimmer to brighter and so on. Some flames flicker at a low frequency, but even those flames that seem to be perfectly steady to the eye, do in fact have amplitude variations (which for convenience herein are being referred to as "flicker") and this flicker can be detected by a photoelectric detector. The rate of flicker is usually too fast to be seen by the eye and its frequency depends to some extent on the type of flame, but it has been found that a substantial amount of 10-50 Hz flame flickers are present in all flames.

A further characteristic of flames that is of interest to flame failure controls is the light transmission of the combustion products. When a flame is burning without enough air for clean burning, free carbon will be produced which causes a smoky flame and smoke in the combustion products.

The radiation properties of oil and p.f. flames are a result of the complex interaction between aerodynamic, chemical and thermal processes. These interactions determine the flame ignition patterns and propagation rates and the formation of flame flicker radiation and pollutants.

Whereas periodic signals may be completely described by their amplitudes, phases and frequencies, random signals are those where future behaviour cannot be predicted and may only be described by quantities such as the power spectral density, and probability distribution.

Power spectrum analysis is useful in characterizing random phenomena such as identifying sources of mechanical vibration and noise. It is also used in characterizing the energy content of a signal. The idealized power spectral densities for both oil and pulverised coal flame flicker are shown in Figures 5 and 6. In these Figures the ordinate is power per Hertz and the abscissa is frequency in Hertz.

From a comparison between the oil flame spectrum of Figure 5 and the p.f. flame spectrum of Figure 6 it will be noted that at the low frequency end (e.g. below 30 Hz) both exhibit strong signals but the contribution from the oil flame tails off more slowly at higher frequencies. Similar considerations apply to gas flames.

Figure 7 shows a practical embodiment of flame detection equipment in accordance with this invention. The equipment basically comprises a flame viewing head 30 and a control unit 31 linked by a cable 36.

The head 30 includes a casing 35 housing a photosensitive device 34 onto which radiation from a selected region of a furnace or boiler is directed via a lens 33 in a sighting tube extension sleeve 32. Conveniently the sleeve 32 is made to be an easy but secure fit to an existing sighting tube of a boiler or furnace whose flame performance is to be monitored but the features to achieve this have not been shown. The casing 35 may include a venting duct 37 to clear moisture from the optics therein when required.

The control unit 31 includes the components shown within the box 50 of the circuit shown in Figure 8 and these will be discussed more fully hereafter, but the unit also includes a digital display 38 and a lamp 39, to give visual indication of the flame condition, and three buttons 40-42. Button 40 is a reset button to set the threshold level and buttons 41 and 42 are "initiate search" buttons which are used in setting up the equipment and in particular putting into the computing memory of the equipment (by using button 41) the digitized frequency spectrum of the radiation entering the casing 35 when the flame being monitored is present in the foreground of the field of view of the head 30 against the background radiation of other flames in the furnace or boiler and (by using button 42) storing the digitized frequency spectrum of only the background radiation entering the head 30.

The unit 31 also includes a mains supply lead 43 and a connector 44 for linking the unit to a remote data processing station.

Referring now to Figure 8, the circuit illustrated comprises a signal conditioning circuit 51 receiving the input from the cable 36 and an ac amplifier 52 whose gain is adjustable by an adjust control 53. The output from the amplifier 52 is fed to a band-pass switched capacitor filter (BSCF) 54 which receives three further inputs. One input is on line 55 from a bank 56 of switches which set the effective "Q" of the BSCF, one input on a line 57 from a central microprocessor 58, and a final input on a line 59 from a clock generator 60 which is controlled by the processor 58.

The line 57 forms part of a self-check system whereby the electrical integrity of integers 54, 61, and 62 are periodically checked. Periodically (e.g. every 5 seconds) a self-check signal is issued by the microprocessor 58.

This signal is fed on line 57 and is designed to turn off the output of the BSCF 54 and hence the output of the threshold detector 62. If the circuit is working properly, removal of the output from the detector 62 should result in a loss of the "flame-on" signal and during the self-check operation the circuit looks to see that the output from detector 62 does momentarily disappear. Thus, a self checking facility is implemented by issuing a self-check signal on the line 54 and monitoring the corresponding response from the output of detector 62.

The BSCF acts as a digitally tunable band-pass filter and accordingly is used to generate a series of ac potential values from the output of the photosensitive device 34, one for each discrete frequency pass band in turn, which together scan the full range of frequencies of interest (i.e. in a typical case 80 to 1500 Hz). The ac values are converted to dc potentials in an ac/dc converter 61 and these dc values are fed both to a threshold detector 62 and to an analog to digital converter 63.

Since the flicker frequency can change with the efficiency of combustion of a given burner fuel, the monitoring equipment described herein can also be used to indicate the onset of non-optimum combustion conditions in the burner being monitored.

The microprocessor 58 is the heart of the circuit shown in Figure 8 and performs the following functions.

Firstly, it stores a first digital signal train representing the radiation received in the head 30 when no flame is present at the monitored burner so that it is pure background radiation which is detected (this signal being entered into the memory of processor 58 when button 42 is pressed). This first signal train is represented graphically in Figure 9A, but in practice would be stored as digital numbers in a hundred or so sub-band memory locations which together cover the entire range of frequencies of interest. The sub-band memory locations are desirably concentrated towards the low end of the spectrum (e.g. 70 to 2000 Hz) since practice shows the optimum flicker frequency is likely to be at the low end for the looked-for flame type.

Secondly, it stores a second digital signal train representing the radiation received in the head 30 when a looked-for fuel flame is present at the monitored burner as seen against the background radiation of the furnace (entered into the memory of processor 58 when button 41 is pressed). This second signal train is represented by Figure 9B, and can again be stored in sub-band memory locations.

Thirdly, it computes the difference between the second and first signal trains and stores this as a third signal train (shown graphically in Figure 9C) which basically represents , historically, the contribution to the signal due to the combustion of the looked-for fuel at the monitored burner.

Fourthly, this third signal train is scanned to determine the frequency at which the peak amplitude occurs and the tunable bandpass filter is then tuned to target the frequency at which the peak amplitude occurred.

These operations have set the unit 31 for future flame monitoring operations for the looked-for type of flame.

The signal obtained from the target flame is compared continuously with a set threshold level in the threshold detector 62 so that whenever the flame signal received, in the frequency range being targeted, is greater than the set threshold level a "flame-on" signal is generated and passed to the microprocessor 58. When the flame signal drops below the set threshold level the "flame-on" signal disappears and an appropriate warning is given.

In essence the threshold detector 62 ignores signal amplitudes below the set threshold level but accepts signals at or above the set level. By virtue of the "tuning" of the bandpass filter to the flicker frequency of the looked-for type of flame, the appearance of a "flame-on" signal can reliably be used by the microprocessor 58 to transmit initiating signals to field devices (not shown) via a failsafe output unit 64 and the connector 44, and to associated controls such as the display 38 and the indicating light 39.

Rather than store both the first and second signal trains, it is possible to temporarily store the first and directly create the difference signal by subtracting the sub-band digital values created by the second train from the temporarily stored first digital values to directly create the required difference signal in the one set of memory locations.

From the above it will be appreciated that the method of the invention resides in the following:-

Random background frequency and existing flame sources are scanned and an analog signal obtained from these sources is passed through the tunable band pass filter 54 and thence through to the microprocessor 58. The frequency spectrum obtained is accepted by the microprocessor and stored as a first series of digital references.

When the flame to be monitored is established, the flame is scanned and new analog signals are obtained from the flame. These signals are then passed through the same tunable band pass filter and thence through to the microprocessor. The signals obtained from this second source are accepted by the microprocessor and then either stored as a second series of digital references with the first series of references for subsequent differencing or the second series of digital references are directly subtracted from the first series and stored as a new series of digital references.

The new series of digital references is then scanned to determine the frequency (or frequencies) at which the peak amplitude occurs and the tunable band pass filter is tuned to target a frequency at which the peak amplitude occurred. This sets the unit 31 for future flame monitoring operations for the looked-for type of flame.

Having set up the unit 31 on the basis of the previous steps, the current output of the opto-electric transducer device (34) is compared with a set threshold level so that whenever the flame signal received is greater than the set threshold level a "flame-on" signal is passed to the microprocessor.

Among the advantages of the method of the invention may be mentioned:-

1. A common device (i.e. the band pass filter) can be used for (i) the initial background and targeted flame flicker analyses and (ii) the actual targeted flame detection.

2. Optimum targeted flame detection will be obtained irrespective of (i) the loading of a boiler, i.e. the intensity of background flames and (ii) flame interferences from neighbouring burners.

3. The flame monitoring equipment can be easily and economically implemented using a microprocessor.

## CLAIMS

1. A method of monitoring a potential flame zone of a burner for the existence of a burner - generated flame of a required type, which method comprises directing radiation received from and through at least a part of said zone onto a photo-sensitive area of an opto-electric transducer device, feeding the output of the transducer device to circuit means adapted to generate an output signal which is related to the radiation falling on the sensitive area and determining from the magnitude of a parameter of the output signal whether there is or is not a flame of the required type in the flame zone, characterised in that the circuit means includes a band-pass filter to eliminate the contributions of radiation having frequencies of amplitude variation (hereafter, for convenience, referred to as "flicker" frequencies) below or above the pass band, in that the pass band of the filter is set to that part of the frequency spectrum where the flicker frequency of a flame of the required type is detectable against background radiation passing through said zone, and in that the output signal in the pass band is used to determine whether a flame of the required type is present in the monitored flame zone.

2. A method according to claim 1, characterised in that the centre frequency of the band-pass filter is tunable and an initial stage of the monitoring method involves setting said centre frequency on the basis of a determination of a difference between the output signal when a flame of the required type is and is not present in said zone.

3. A method according to claim 2, characterised in that the centre frequency is selected to correspond to the maximum amplitude of said difference signal.

4. A method according to claim 1, characterised in that the pass band of the filter lies in the range 70 to 2000 Hz.

5. A flame monitoring device comprising an opto-electric transducer and signal processing equipment to act on the electrical output of the transducer and generate a "flame-on" signal in the presence of a looked-for flame in a monitored flame zone, characterised in that the signal processing equipment includes means to determine a flicker frequency which is sensitive to the presence or absence of the looked-for flame, a band-pass filter to receive the output of the transducer, a threshold device to receive the output of the band-pass filter and generate the "flame-on" signal and means to tune the band-pass filter to the determined flicker frequency.

6. A flame monitor device according to claim 5, characterised in that a sighting tube leading directly towards the flame zone is used to direct radiation to the photo-sensitive area of the opto-electric transducer.

7. A flame monitor device according to claim 6, characterised in that the sighting tube includes lens means to focus the radiation from the flame zone onto the said area.

8. A flame monitor device according to claim 5, characterised in that the band-pass filter is a tunable band-pass switched capacitor filter circuit.

9. A flame monitor device according to claim 8, characterised in that the tunable band-pass switched capacitor filter circuit feeds its output into an AC/DC converter and then to the threshold device.

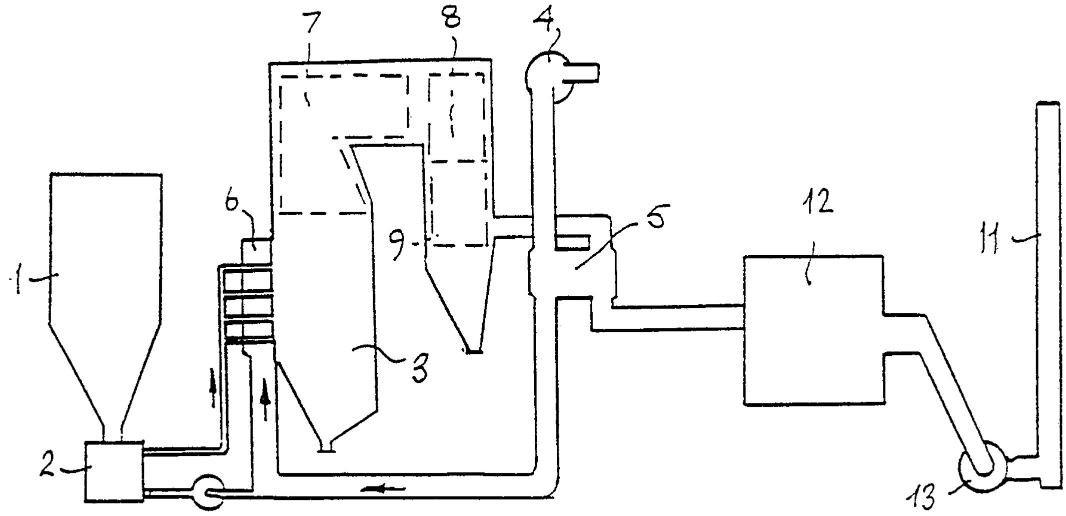



FIG.1

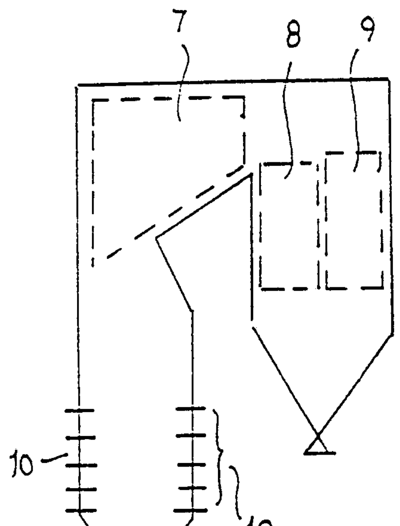



FIG.2

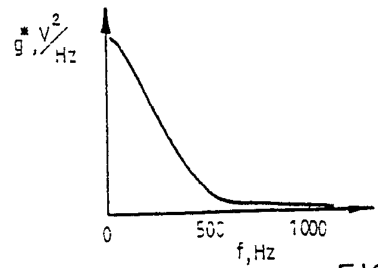



FIG 5

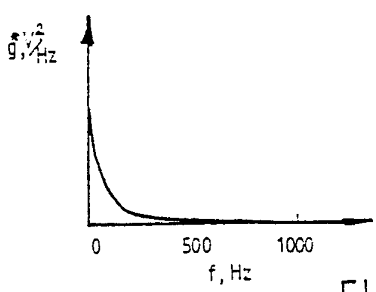



FIG.6

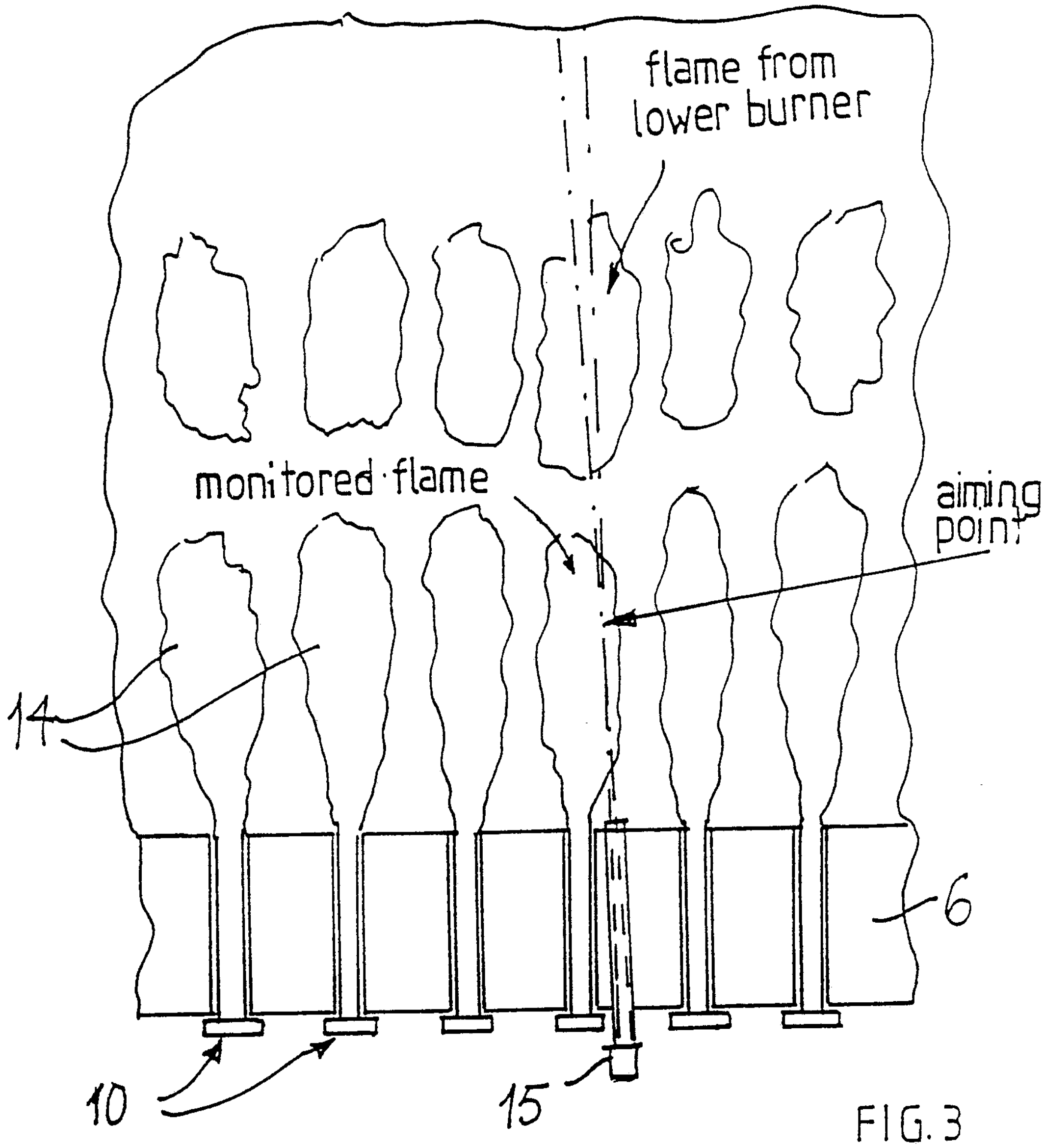

flame from
lower burner
monitored flame
aiming
point
14
6
10
15

FIG. 3

3/5

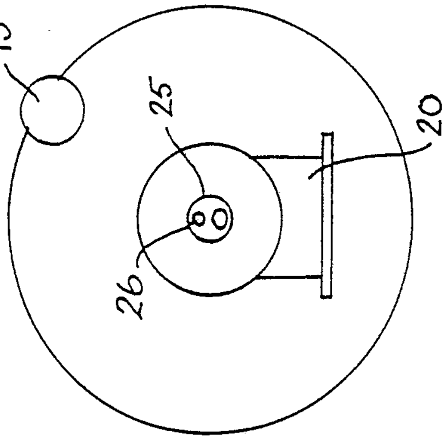



FIG.4A

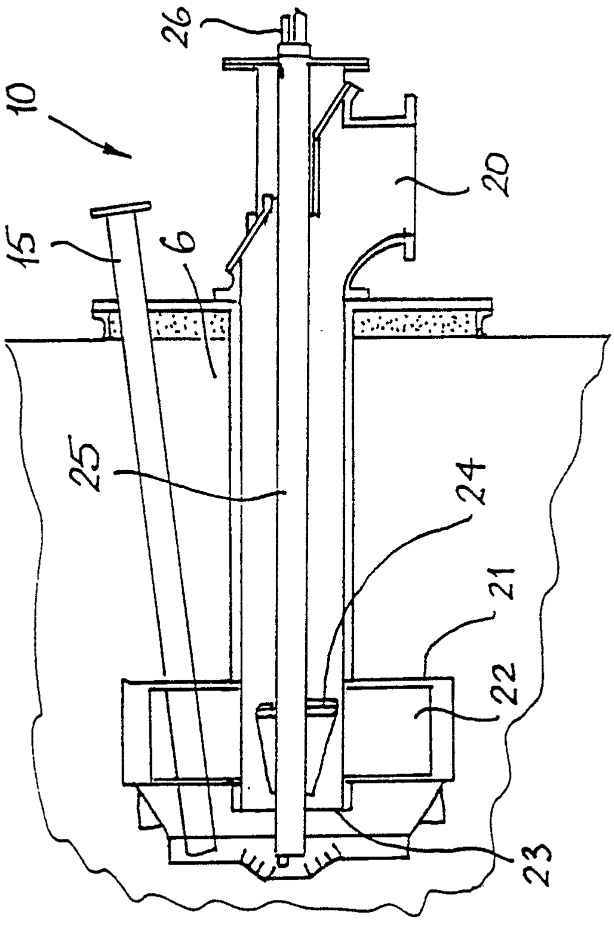



FIG.4

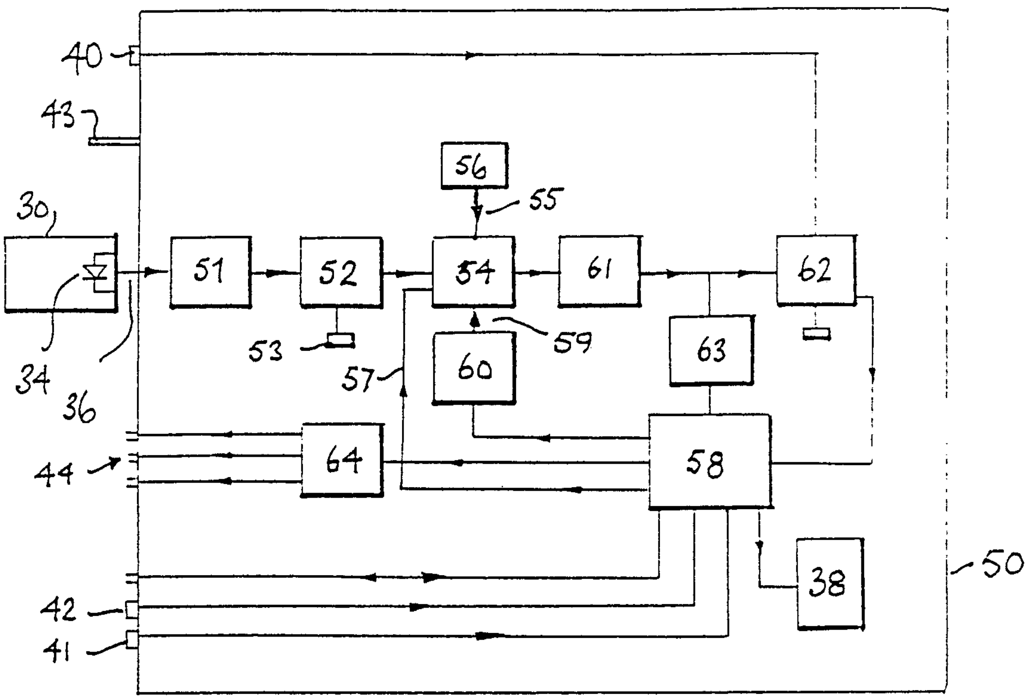



FIG. 8

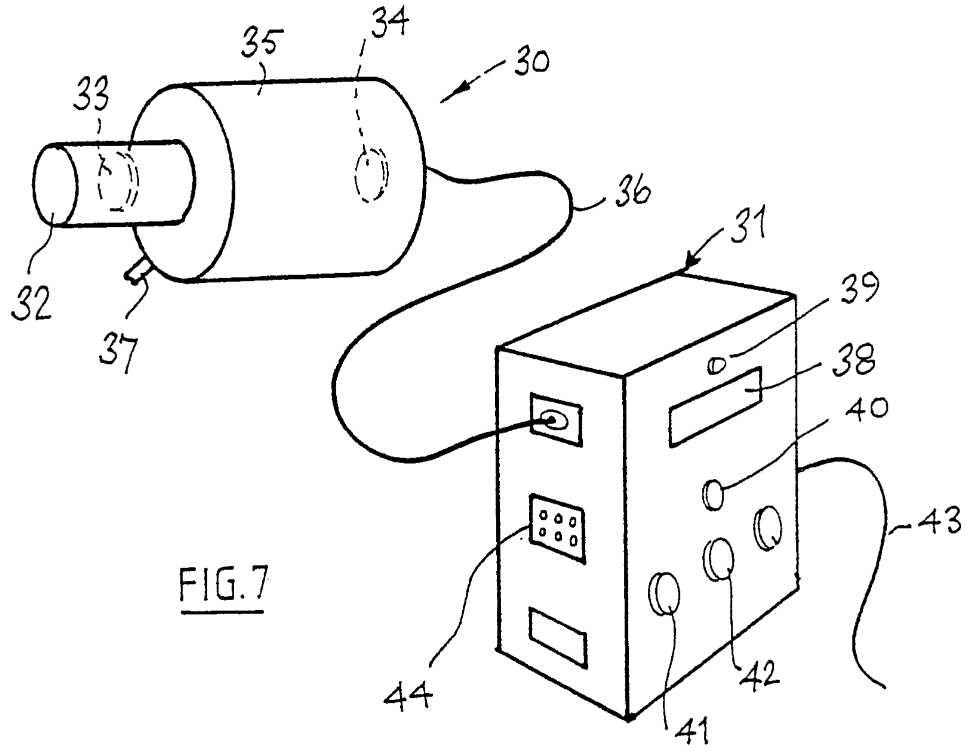



FIG. 7

SUBSTITUTE SHEET

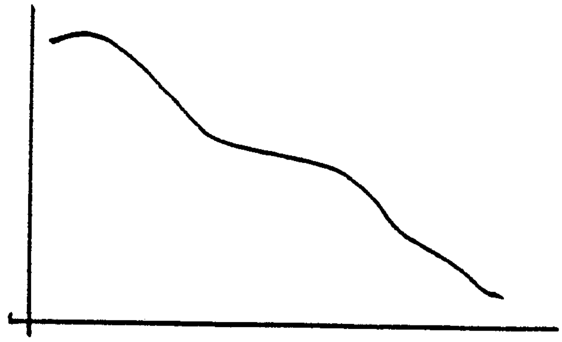


FIG. 9A

FIG.9B

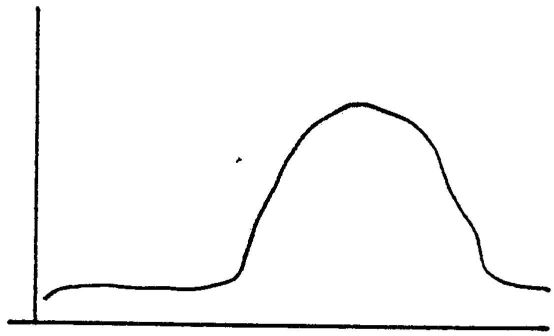


FIG.9C

# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00468

**I. CLASSIFICATION OF SUBJECT MATTER** (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 F23N5/08

**II. FIELDS SEARCHED**

Minimum Documentation Searched[7]

| Classification System | Classification Symbols |
|---|---|
| Int.Cl. 5 | F23N |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

**III. DOCUMENTS CONSIDERED TO BE RELEVANT**[9]

| Category ° | Citation of Document, [11] with indication, where appropriate, of the relevant passages [12] | Relevant to Claim No.[13] |
|---|---|---|
| X | DE,A,1960218 (PORTSCHT) 03 June 1971<br>see the whole document<br>--- | 1-3, 5-7 |
| X | GB,A,2132342 (BOOTH) 04 July 1984<br>see the whole document<br>--- | 1, 4, 5 |
| X | US,A,3903418 (HORN) 02 September 1975<br>see abstract; figures<br>--- | 1-3, 5 |
| X | PATENT ABSTRACTS OF JAPAN<br>vol. 13, no. 76 (M-800)(3424) 21 February 1989,<br>& JP-A-63 273726 (TOYOTA) 10 November 1988,<br>see the whole document<br>--- | 1, 2, 5 |
| A | US,A,4509041 (KEYES ET AL.) 02 April 1985<br>see column 4, line 59 - column 5, line 3; figure 6<br>---<br>-/-- | 2, 8, 9 |

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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**IV. CERTIFICATION**

| Date of the Actual Completion of the International Search | Date of Mailing of this International Search Report |
|---|---|
| 07 JUNE 1991 | 19.07.91 |
| **International Searching Authority** | **Signature of Authorized Officer** |
| EUROPEAN PATENT OFFICE | KOOIJMAN F.G.M. |

| III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) | | |
|---|---|---|
| Category ° | Citation of Document, with indication, where appropriate, of the relevant passages | Relevant to Claim No. |
| A | GB,A,1500771 (TALENTUM DEVELOPMENTS LIMITED) 08 February 1978 --- | |

# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL P. ;ENT APPLICATION NO.

GB 9100468
SA 46355

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 10/06/91
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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| DE-A-1960218 | 03-06-71 | None | |
| GB-A-2132342 | 04-07-84 | DE-A- 3344358 | 14-06-84 |
| | | JP-A- 59170618 | 26-09-84 |
| US-A-3903418 | 02-09-75 | AU-A- 7437474 | 29-04-76 |
| | | CA-A- 1043445 | 28-11-78 |
| | | DE-A,C 2451449 | 19-06-75 |
| | | FR-A,B 2254756 | 11-07-75 |
| | | GB-A- 1496666 | 30-12-77 |
| | | JP-A- 50093491 | 25-07-75 |
| | | NL-A- 7414566 | 17-06-75 |
| | | US-A- 3902841 | 02-09-75 |
| US-A-4509041 | 02-04-85 | CA-A- 1202703 | 01-04-86 |
| GB-A-1500771 | 08-02-78 | None | |



For more details about this annex : see Official Journal of the European Patent Office, No. 12/82