(12) **UK Patent Application** (19) **GB** (11) **2 412 958** (13) **A**

(43) Date of A Publication 12.10.2005

(21) Application No: 0415052.0

(22) Date of Filing: 05.07.2004

(30) Priority Data:
(31) 0408102 (32) 08.04.2004 (33) GB

(71) Applicant(s):
Autoflame Engineering Limited
(Incorporated in the United Kingdom)
Unit 19, Bellingham Trading Estate,
Franthorne Way, Bellingham, LONDON,
SE6 3BX, United Kingdom

(72) Inventor(s):
Brendan Kemp
Paul James Nichols

(74) Agent and/or Address for Service:
Abel & Imray
20 Red Lion Street, LONDON, WC1R 4PQ,
United Kingdom

(51) INT CL⁷:
F22B 37/56 // F22D 5/30

(52) UK CL (Edition X):
F4A A44B1X A44B2X

(56) Documents Cited:
GB 2374135 A **US 6655322 B1**
US 20030226794 A

(58) Field of Search:
UK CL (Edition W) **F4A**
INT CL⁷ **F22B, F22D**
Other: **EPODOC, JAPIO, WPI**

(54) Abstract Title: **Measuring of total dissolved solids in a steam boiler**

(57) A probe 74 for measuring the total dissolved solids is associated with an outlet pipe 72 of the pressurised steam boiler 50. A control unit 1 receives signals from the probe and controls the operation of motorised valves 71 and 73. The control unit also receives signals from a temperature detector 59, a pressure detector 61, and a water level detector 62 to control the flow rate of water into the boiler, the blow down of the boiler, and the firing rate of a burner 20. The burner includes a burner head 21 leading to a combustion chamber 22, and a duct 23, for exhausting combustion products via the boiler. The control unit is also connected via an exhaust gas analyser 37 to an exhaust gas analysis probe 38, and to a flame detection unit 40 at the burner head. The method of control of the boiler may alternatively include the step of measuring the conductivity of water contained in the boiler, the step of measuring the degree of polarisation of the water whose conductivity is measured, or the step of providing a water sampling probe assembly, all for assessing the level of total dissolved solids in the water.
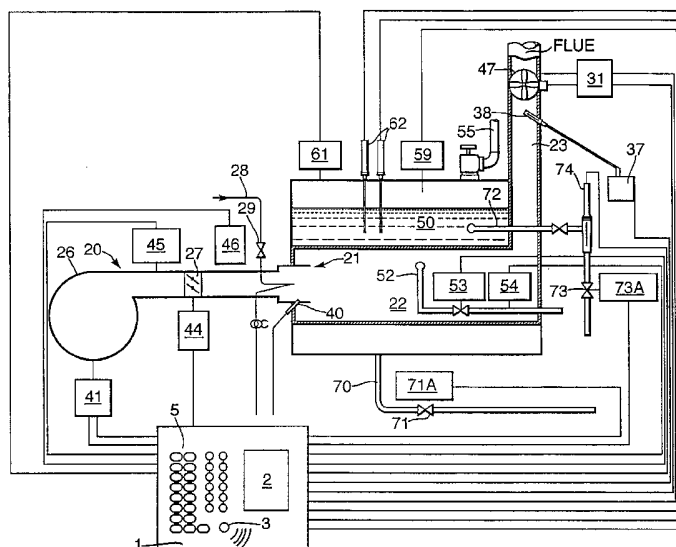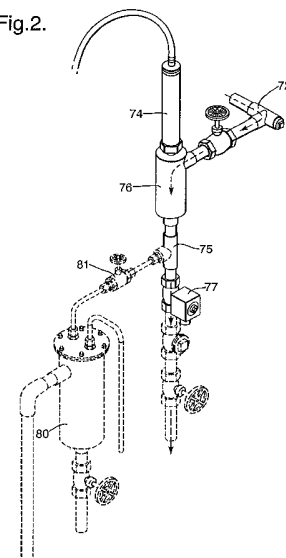
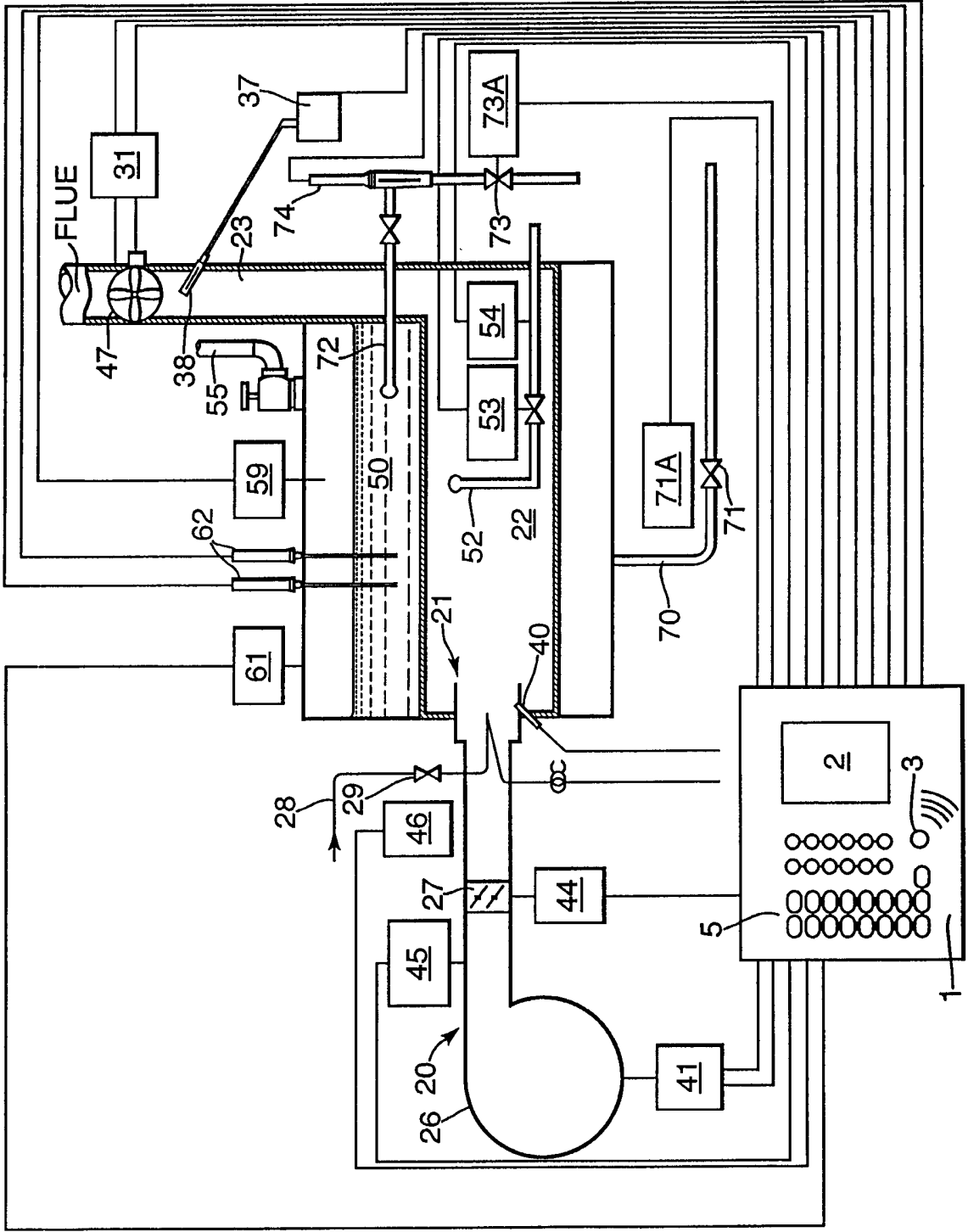Fig.1.

Fig.2.

GB 2 412 958 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Original Printed on Recycled Paper

Fig.1.

Fig.2.
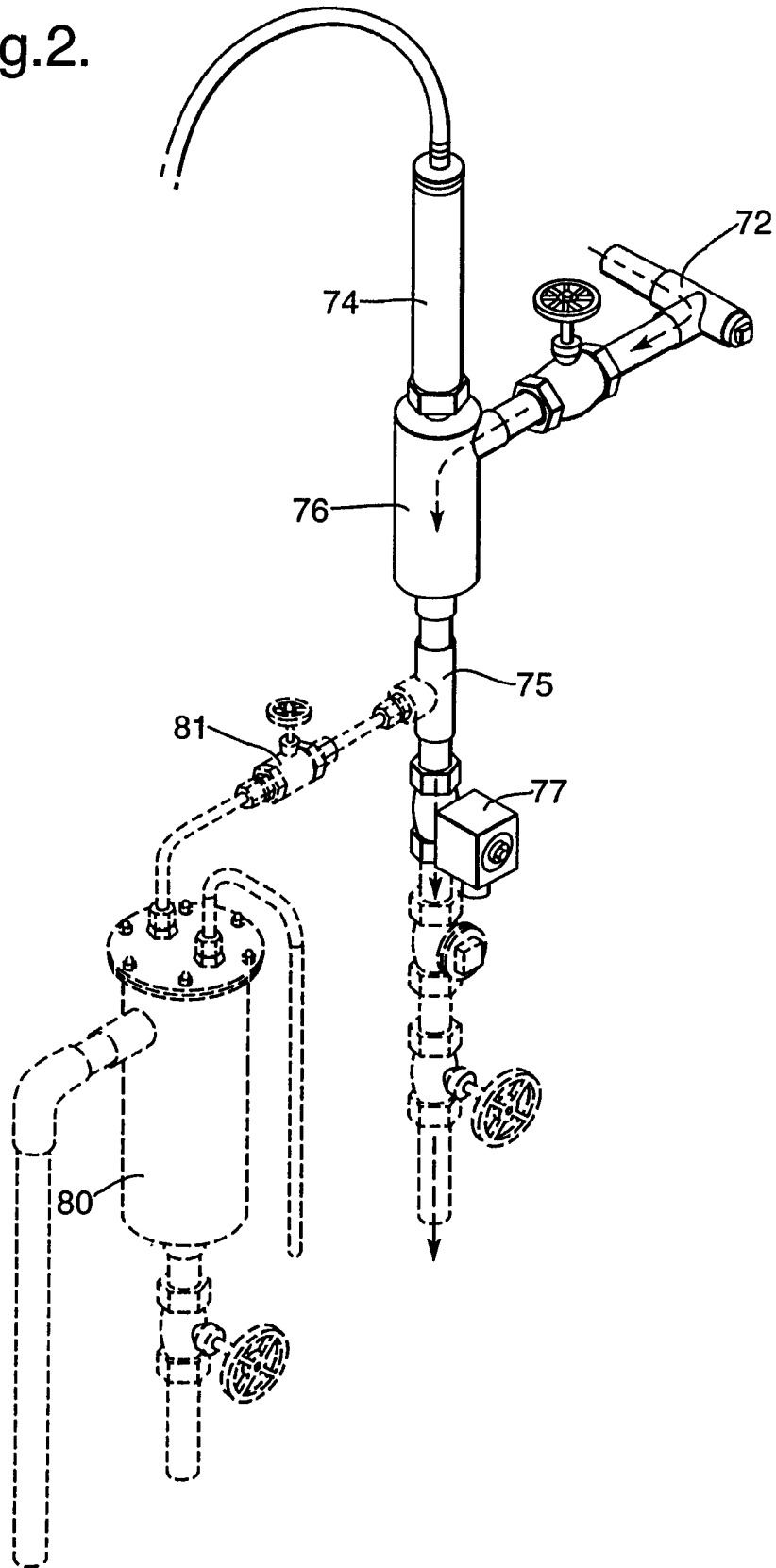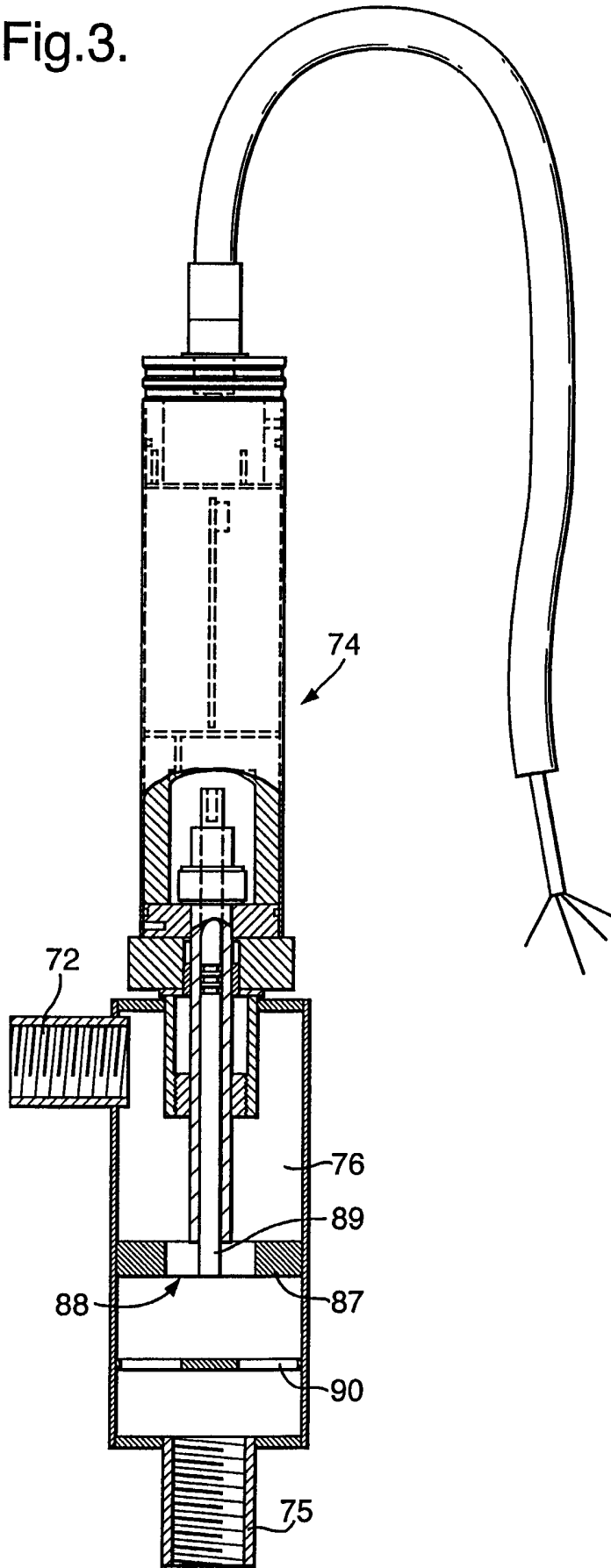
74

72

76

75

81

77

80

Fig.3.

Apparatus and Method for measuring total dissolved solids in a steam boiler

The invention relates to steam boilers and their
control, and more particularly to a method and apparatus
for measuring the total dissolved solids in the water of a
steam boiler.

In a known arrangement of a steam boiler, water is fed
into the boiler at a controlled rate and is heated in the
boiler to convert the water to steam. The heat required to
convert the water to steam is provided by a burner whose
hot products of combustion are passed through ducts in the
boiler and then exhausted. The steam boiler is controlled
by a boiler control system, which receives information from
sensors indicating, *inter alia*, the level of water in the
boiler and the pressure of steam in the boiler, and which
controls the flow rate of water into the boiler as well as
sending a control signal to a burner control system that
controls the burner. The burner control system controls,
inter alia, the flow of fuel and gas to the burner head in
dependence upon a demand signal received from the boiler.

The water that is fed in to the boiler will, even when
pre-treated, generally contain some solids in solution.
The steam boiler increases the concentration of the
solution through the evaporation of steam. If the level of
total dissolved solids is increased, precipitate begins to
form on surfaces within the boiler, leading to premature

boiler failure, slower heat exchange rates and a reduction in the efficiency of the steam boiler.

One factor that may be taken into account to ensure the steam boiler functions efficiently is the level of
5   total dissolved solids in the water, which should be maintained below a predetermined and preselected maximum level. The level of dissolved solids may be reduced by blowing down the steam boiler. During blow down the concentrated boiler water is partly replaced by feed
10 water. Blowing down the boiler frequently can keep the average total dissolved solids well below the predetermined maximum, but heat is lost with the water discharged from the steam boiler and the efficiency of the steam boiler is reduced. More efficient operation can be obtained by
15 blowing down the steam boiler to maintain the average level of total dissolved solids at a value almost equal to the preselected maximum value.

It is an object of the invention to provide an improved method and apparatus for controlling the operation
20 of a steam boiler and reducing or avoiding any unnecessary blow down of the boiler.

According to the invention there is provided a method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the following
25 steps:

a)   monitoring the level of total dissolved solids in water contained in the boiler,

b)   monitoring the level of water in the boiler,

c) monitoring the pressure of steam in the boiler,

d) monitoring the firing rate of the burner,

e) controlling blow down of the boiler having regard to the signals resulting from a),

5   f) controlling the flow rate of water into the boiler, and

g) controlling the firing rate of the burner,

all input signals relating to the monitoring steps being passed to the common control unit and all output signals

10 relating to the controlling steps being transmitted from the common control unit.

By combining the control of the boiler and burner in the manner defined above, it becomes possible to provide a very effiecient method for controlling the level of total

15 dissolved solids in the water.

The step of controlling the firing rate of the burner may include controlling the fuel flow and may also include controlling the air flow. The air flow may be controlled by adjusting the position of an air damper and/or by

20 adjusting the speed of a fan that generates the air flow into the burner.

Preferably the amount of blow down of the boiler is controlled according to the firing rate of the burner. The rate of generation of total dissolved solids is

25 proportional to the evaporation rate of water from the boiler and is therefore approximately proportional to the firing rate of the burner. It is therefore preferable that the amount of blow down of the boiler is controlled

approximately in proportion to the firing rate of the burner. The amount of blow down may be altered by altering the length of the blow down but is preferably altered by altering the standard time interval between blow downs.

5   It is also preferable that during the initial heating of the water in the boiler to its operating temperature and pressure, no blow down is carried out since that would only delay the running up of the boiler to its steady state running condition. Thus it is preferred that

10 blow down of the boiler is inhibited until the pressure of steam in the boiler reaches a predetermined level.

    In accordance with an especially preferred feature of the invention, the step of monitoring the level of total dissolved solids in water in the boiler includes

15 the step of measuring the temperature of the water contained in the boiler, and assessing the level of total dissolved solids having regard to the temperature of the water in the boiler. If such a method is used, it is possible to make the measurement of total dissolved solids

20 online since there is no need to cool the water first to a standard temperature.

    Whilst there are a variety of ways of measuring total dissolved solids in water, it is preferred that the measurement is made principally by measuring the

25 conductivity (the electrical conductivity) of a sample of water in the boiler. Such a method of measuring total dissolved solids is already known *per se*. In accordance with an especially preferred feature of the invention, the

conductivity of the water is measured using pulses of electrical energy that are emitted only for a proportion of the time during which the conductivity measurement is being made. By adopting such a pulsed system, build-up of polarisation of the water sample is to a large extent avoided. Preferably the pulses include both positive and negative pulses and more preferably the pulses are of alternating polarity. In order to further reduce the build-up of polarisation, the pulses are preferably emitted for less than 10%, and most preferably for less than 1%, of the time during which the conductivity measurement is being made. In a preferred embodiment of the invention, the pulses are emitted for only 0.6% of the time.

According to another especially preferred feature of the invention, the step of monitoring the level of total dissolved solids in water in the boiler includes the step of measuring the degree of polarisation of the sample of water whose conductivity is measured and taking the polarisation measurement into account in the assessment of the level of total dissolved solids. By making an adjustment to allow for the degree of polarisation, it becomes possible to obtain a more accurate measurement of the level of total dissolved solids.

Although it is within the scope of the invention to monitor the total dissolved solids of a sample of water while that sample is contained within the boiler, it is preferred that the step of monitoring the level of total dissolved solids in water contained in the boiler includes

the step of removing a sample of water from the boiler.
Preferably, water is removed from the boiler and passed
along a conduit through a water sampling probe assembly.
The water sampling probe assembly may receive water from

5   any part of the boiler but preferably receives surface blow
down water. "Surface blow down water" is hereby defined as
water taken from closer to the top surface of the water
than to the bottom of the boiler.

According to another especially preferred feature of

10   the invention, water flow through the water sampling probe
assembly is turbulent and effects a cleaning action on the
water sampling probe assembly. Such an arrangement is
advantageous in that it promotes reliable measurements of
total dissolved solids in the long term. It is also

15   preferred that when water is removed from the boiler to
reduce the level of total dissolved solids, it is passed
through the water sampling probe assembly. This enhances
the cleaning action.

Preferably, the measuring tip of the probe

20   assembly is located in a region where the cross-sectional
area of the water flow path is reduced. Such an
arrangement enhances the turbulence of the water in the
region of the measuring tip. The cross-sectional area of
the water flow path may be reduced by an apertured plate

25   provided across the water flow path. The measuring tip of
the probe may be provided in the region of an aperture in
the plate or may be spaced from any aperture in the plate.

Preferably the assessment of the level of total

dissolved solids is made having regard to the measurement of the pressure of steam in the boiler.

In response to an indication that the level of total dissolved solids in the water contained in the boiler

5   exceeds a predetermined maximum value, a boiler blow down sequence is preferably commenced.

The level of total dissolved solids in the water contained in the boiler is preferably monitored periodically.

10   According to the invention there is also provided a pressurised steam boiler including

a boiler housing for containing water in a boiler,

a burner for heating water in the boiler and

15   converting the water into steam,

a total dissolved solids detector for monitoring the level of total dissolved solids in the water in the boiler,

a water level detector for monitoring the level

20   of water in the boiler,

a pressure detector for detecting the pressure of steam in the boiler,

a firing rate detector for detecting the firing rate of the burner, and

25   a common control unit which receives input signals from the total dissolved solids detector, the water level detector, the pressure detector and the firing rate detector, and is operative to control the flow rate of

water into the boiler, blow down of the boiler and the firing rate of the burner in dependence upon said input signals.

The pressurised steam boiler may further include features suited to carrying out any of the preferred features of the method defined above.

Whilst the method and boiler of the invention are preferably provided in the context of a common control unit, as indicated above, the especially preferred features of the invention referred to above may also, in accordance with the invention, be applied in other arrangements which may not necessarily employ a common control unit. Thus there are the further aspects of the invention set out below.

According to a further aspect of the invention, there is provided a method of controlling the operation of a pressurised steam boiler heater by a burner, the method including the following steps:

(a) measuring the conductivity of water contained in the boiler,

(b) measuring the temperature of water contained in the boiler, and

(c) assessing the level of total dissolved solids in the water having regard to the results of the conductivity and temperature measurements.

According to a still further aspect there is provided a method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the

following steps:

    (a)   measuring the conductivity of water contained in the boiler, and

    (b)   assessing the level of total dissolved solids

5   having regard to the results of the conductivity measurement,

wherein the conductivity of the water is measured using pulses of electrical energy that are emitted only for a proportion of the time during which the conductivity

10   measurement is being made.

    According to a still further aspect of the invention there is provided a method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the following steps:

15   (a)   measuring the conductivity of water contained in the boiler,

    (b)   measuring the degree of polarisation of the water whose conductivity is measured, and

    (c)   assessing the level of total dissolved solids

20   having regard to the conductivity and polarisation measurements.

    According to a still further aspect of the invention there is provided a method of controlling the operation of a pressurised steam boiler heated by a burner,

25   the method including the following steps:

    (a)   providing a water sampling probe assembly for measuring total dissolved solids, the probe assembly being connected to receive water

contained in the boiler via a conduit,

(b)   passing water from the boiler through the water

sampling probe assembly, and

(c)   using the water sampling probe assembly to

5   measure the conductivity of the water passing

through the assembly,

wherein the water flow through the water sampling probe

assembly is turbulent and effects a cleaning action on the

water sampling assembly.

10   The methods defined above and according to other

aspects of the invention may of course, wherever

appropriate, employ any of the features already defined

with respect to the first-mentioned aspect of the

invention.

15   Similarly, there is provided according to a further

aspect of the invention a pressurised steam boiler

including:

a boiler housing for containing water in a

boiler,

20   a burner for heating water in the boiler and

converting the water into steam,

a conductivity detector for measuring water

conductivity, and

a temperature detector for detecting the

25   temperature of the water contained in the boiler,

wherein the signal from the conductivity detector is

arranged to be modified in dependence upon the temperature

measurement to provide an indication of the total dissolved solids in the water.

According to a still further aspect of the invention there is provided a pressurised steam boiler including:

5   a boiler housing for containing water in a boiler,

a burner for heating water in the boiler and converting the water into steam, and

a conductivity detector for measuring water

10   conductivity,

wherein the conductivity detector is arranged to emit pulses of electrical energy only for a proportion of the time during which the conductivity measurement is being made.

15   According to a still further aspect of the invention there is provided a pressurised steam boiler including:

a boiler housing for containing water in a boiler,

a burner for heating water in the boiler and

20   converting the water into steam,

a conductivity detector for measuring water conductivity, and

a polarisation detector for measuring the degree of polarisation of the water whose conductivity

25   is to be measured,

wherein the signal from the conductivity detector is arranged to be modified independence upon the polarisation measurement to provide an indication of total dissolved

solids in the water.

According to a still further aspect of the invention there is provided a pressurised steam boiler including:

a boiler housing for containing water in a
5   boiler,

a burner for heating water in the boiler and converting the water into steam, and

a water sampling probe assembly connected to the interior of the boiler housing by a conduit for
10   measuring the total dissolved solids of water contained in the boiler,

wherein the water flow through the water sampling probe assembly is arranged to be turbulent and to effect a cleaning action on the water sampling probe assembly.

15   The apparatus defined above and according to other aspects of the invention may of course, wherever appropriate, employ any of the features already referred to with respect to the first-mentioned aspect of the invention.

20   The method and apparatus of the invention may also incorporate any of the features of the steam boiler and its method of operation that are described in WO 02/079695, the contents of which are incorporated herein by reference.

By way of example, an embodiment of the invention
25 will now be described with reference to the accompanying drawings, of which:

Fig. 1   is a schematic drawing of a burner and a
           pressurised steam boiler and of a control

unit for controlling the burner and steam boiler,

Fig. 2   is a perspective view of an installation of a water sample probe assembly for use in the present invention, and

Fig. 3   is a sectional view of the water sample probe assembly of Fig. 2.

Referring first to Fig 1, there is shown a burner 20 having a burner head 21, a combustion chamber 22 and a duct 23 for combustion products which comprise exhaust gases. As will be described below the duct 23 passes through a pressurized steam boiler 50; thereafter the exhaust gases are vented through a flue.

Air is fed to the burner head 21 from an air inlet, through a centrifugal fan 26 and then through an outlet damper 27. The burner head 21 is able to operate with either gas or oil as the fuel; gas or oil is fed to the burner head from along a line 28 and via a valve 29.

A control unit 1 is provided for controlling the operation of the burner and boiler. The control unit 1 is provided for controlling the operation of the burner and boiler. The control unit 1 has a display 2, optionally a proximity sensor 3 for detecting that a person is nearby, and a set of keys 5 enabling an operator to enter instructions to the control unit. The purpose of the proximity sensor is not relevant to the present invention and will not be described further herein; its purpose is described in GB2335736A, the description of which is

incorporated herein by reference.

The control unit 1 is connected to various sensing devices and drive devices, as shown in the drawing. More particularly the unit is connected via an exhaust gas

5 analyser 37 to an exhaust gas analysis probe 38 (which includes a temperature sensor), and to a flame detection unit 40 at the burner head. The control unit 1 is also connected via a variable speed drive control 41 to the motor of the fan 26 (with control unit 41 receiving a feed

10 back signal from a tachometer associated with the fan 26), via an air servo motor 44 to the air outlet damper 27, to an air pressure sensing device 45 provided in the air supply duct, via a fuel servo motor 46 to the fuel valve 29, and via a variable speed device 31 to a fan 47 in the

15 flue.

Also, in the embodiment of Fig. 1, the boiler 50 is provided with a steam outlet pipe 55, a water inlet pipe 52 which feeds water into the boiler via a feedwater valve 53 controlled by a servo 54. A temperature detector 59 senses

20 the temperature of the water in the boiler (by measuring the temperature of the steam which indicates the temperature of the water once the boiler is up to its running temperature range). The pressure of the steam in the boiler is sensed by a pressure detector 61 and a pair

25 of capacitance probes 62 monitor the level of the water in the boiler. The control unit 1 is connected to the feedwater valve servo 54, the temperature detector 59, the pressure detector 61 and the pair of capacitance probes 62.

Other monitoring and control devices may also be provided and connected to the control unit 1.

In general, the arrangement described above is the same as that described in more detail in WO 02/079695, the
5   contents of which is incorporated herein by reference.

Of particular relevance to the present invention, is an outlet pipe 70 at the bottom of the boiler having an associated motorised valve 71 controlled by the control unit 1 for effecting bottom blow down of the boiler and
10 another outlet pipe 72 towards the top of the boiler but below the minimum water level maintained in the boiler, the outlet pipe 72 having an associated motorised valve 73 controlled by the control unit 1 for effecting surface blow down of the boiler.

15   As will be described in more detail below, a probe 74 for measuring total dissolved solids (TDS) and referred to hereafter as a TDS probe is associated with the outlet pipe 72. The control unit 1 receives signals from the TDS probe and controls the operation of the motorised valves 71
20 and 73 via servos 71a and 73a.

The combustion chamber 22 of the burner 20 is arranged inside the boiler 50 in a conventional manner. In Fig 1 the boiler 50 is shown schematically. Although Fig 1 suggests that the combustion chamber leads directly to the
25 exhaust duct 23, it will be understood by those skilled in the art that in practice the gaseous products of combustion follow a serpentine path passing through the boiler 50 a

few times before reaching the exhaust duct 23 and being exhausted to atmosphere.

Referring now to Figs. 2 and 3, the outlet pipe 72 is connected via an isolation valve to the top of an interior
5   chamber 76 of the TDS probe 74. The chamber 76 has an outlet pipe 75 at its bottom which is opened and closed by a solenoid valve 77 (the equivalent to the valve 73 and servo 73a in Fig. 1) controlled by the control unit 1. The outlet pipe 75 leads to a drain. A plate 87 extends across
10   the chamber 76 and has an orifice 88 in its centre. The measuring tip 89 of the probe projects downwardly into the middle of the orifice 88. Below the plate 87, a baffle plate 90 is provided, the baffle plate 90 having four apertures equiangularly spaced around the centre of the
15   plate.

Also shown in dotted outline in Fig. 2 is a sample cooler 80 which may be connected via a valve 81 to the outlet pipe 75 to receive surface blow down water from the boiler. Such a device may be used to calibrate the TDS
20   probe 74 as will be described later.

The TDS probe 74 may operate in a manner known *per se* by measuring the electrical conductivity of water passing through the probe. Thus the control unit 1 may, for example, be arranged to feed surface blow down water
25   through the TDS probe periodically (typically once every one to five minutes) and for a period of time selected by the user (typically 3 to 10 seconds) in order to measure the total dissolved solids. A preferred feature of the

invention is that in the event that the total dissolved solids measurement indicates a level of solids above a maximum predetermined level, a top blow down of the boiler is carried out by the control unit 1. The duration of that

5   blow down is at the selection of the user but would usually be longer than the duration of the blow down for the purposes of sampling. Typically, the duration would be in the range of 5 seconds to 5 minutes.

The rate of sampling of the total dissolved solids in

10 the water can also be set in the control unit by a user and would typically be set to a rate in the range of one sample every one to five minutes. The actual standard rate of sampling is varied by the control unit 1 in proportion to the firing rate of the boiler, which is also controlled by

15 the control unit 1. If the firing rate of the boiler is at maximum then the standard rate of initiating a top blow down is also at a maximum. If for example the firing rate is halved, then the time interval between top blow downs is doubled. In this way it is possible to avoid unduly

20 frequent or large blow downs at low firing rates of the boiler. Such blow downs would be wasteful of energy used to heat the water. The control unit 1 is also arranged to sample the water again immediately after any surface blow down that has been carried out and detected too high a

25 level of total dissolved solids. Furthermore, when the water in the boiler is first being heated to its steady state operating condition, the control unit is arranged not to effect any blow down and therefore not to slow down the

heating of the water. The pressure detector 61 measures
the pressure of steam in the boiler and that pressure
measurement is used to inform the control unit 1 as to
whether the boiler is within its steady state range of
5   operating conditions, If the pressure detected is below
that range blow down is prevented.

In accordance with especially preferred features of
the invention, the system is arranged to make a more
accurate measurement of total dissolved solids in the
10 water, by virtue of the following.

Firstly, the control unit 1 makes use of the
temperature measurement of the water in the boiler, as
measured by the detector 59, to adjust the conductivity
measurement made by the TDS probe 74 and therefore obtain a
15 truer reading. More specifically, for every 1°C of
increase in temperature the conductivity measurement is
reduced by 2 per cent to give a truer value, and *vice
versa*.

Secondly, steps are taken to reduce polarisation of
20 the water sample whose conductivity is being measured.
Instead of passing electrical energy continuously through
the probe, the energy is pulsed with there being 10 pulses,
each of 300µS duration, each second. Thus the amount of
electrical energy is reduced to just 0.6% of the amount
25 that would be used if the energy were supplied continuously
during sampling. Separate readings of total dissolved
solids are obtained from each of the 10 pulses and the
average of those results is then taken as the reading. The

system is arranged to take the last ten such readings and average them to arrive at a fixed value so that any one measurement from one pulse only contributes one per cent of the final reading. Furthermore, the polarity of the pulses is alternated so that again polarisation is reduced, In a particular sample of the invention the pulses are ± 0.5 volts and the current measurement is of the order of milliamps.

Thirdly, in addition to reducing the amount of polarisation, an adjustment of the conductivity measurement is made according to any remaining degree of polarisation. At the commencement of each measurement cycle, the probe 74 measures any build up of voltage potential in the water sample and modifies the conductivity calculation accordingly. In a particular example of the invention, one complete measurement cycle comprises the following sequence: a voltage check for 0.3 milliseconds to check the polarisation of the sample; an interval of 0.7 milliseconds; a voltage pulse of + 0.5 volts for 0.3 milliseconds to allow a first conductivity measurement; an interval of 0.7 milliseconds; a voltage pulse of - 0.5 volts for 0.3 milliseconds to allow a record conductivity measurement; and an interval of 0.7 milliseconds. Thus one measurement cycle occupies 3 milliseconds. Every one second a new conductivity reading is obtained by averaging the last ten measurements which are spread over a one second time interval.

Fourthly, steps are taken to avoid a build up of scale

on the probe electrode. The interior chamber 76 of the
probe assembly is designed so that the turbulence created
by the water during blow down cleans the measuring tip 89
of the probe 74. The positioning of the tip 89 in the
5   orifice 88 ensures that the tip is exposed to turbulent
flow. It should be noted that water passes through the
chamber 76 both during sampling of the water and during any
more prolonged blow down to reduce the level of total
dissolved solids in the water. In some circumstances a
10   user may wish to reverse the flow of water through the
chamber 76 and in this case the apertured plate 90 is
effective in promoting turbulence in the chamber,
especially in the vicinity of the tip 89 of the probe 74.

As a result of the steps referred to above, an
15   especially accurate measurement of total dissolved solids
can be obtained.

The TDS probe 74 can be calibrated in a variety of
ways. For example, during operation of the boiler a sample
of water can be taken and passed both through the probe 74
20   and into the sample cooler 80 (Fig. 2). The reading from
the probe 74 can be taken and stored together with a
reading of the temperature of the water. The water in the
sample cooler 80 can then be cooled to 25°C and the amount
of total dissolved solids in that water measured using a
25   hand held portable instrument, for example the type H198312
instrument manufactured by "Hanna Instruments". By
comparing the reading from the probe 74 with the reading at
25°C the probe 74 can be calibrated. If desired, the

calibration step can be repeated. If preferred, the probe 74 can also be calibrated automatically under the control of the control unit 1.

Whilst one particular embodiment of the invention has been described, it will be understood that many variations are possible. As one example of such a variation, the probe 74 may be mounted horizontally rather than vertically as shown in Fig. 2.

Claims:

1.   A method of controlling the operation of a
pressurised steam boiler heated by a burner, the method
including the following steps:

5   a)   monitoring the level of total dissolved solids in
              water contained in the boiler,

        b)   monitoring the level of water in the boiler,

        c)   monitoring the pressure of steam in the boiler,

        d)   monitoring the firing rate of the burner,

10   e)   controlling blow down of the boiler having regard
              to the signals resulting from a),

        f)   controlling the flow rate of water into the
              boiler, and

        g)   controlling the firing rate of the burner,

15 all input signals relating to the monitoring steps being
    passed to the common control unit and all output signals
    relating to the controlling steps being transmitted from
    the common control unit.

20   2.   A method according to claim 1, in which the
    amount of blow down of the boiler is controlled according
    to the firing rate of the burner.

        3.   A method according to claim 2, in which the
25 amount of blow down of the boiler is approximately
    proportional to the firing rate of the burner.

        4.   A method according to claim 2 or 3, in which the

amount of blow down of the boiler is varied by altering the standard time interval between blow downs.

5. A method according to any preceding claim, in which blow down of the boiler is inhibited until the pressure of steam in the boiler reaches a predetermined level.

6. A method according to any preceding claim, in which the step of monitoring the level of total dissolved solids in water in the boiler includes the step of measuring the temperature of the water contained in the boiler, and assessing the level of total dissolved solids having regard to the temperature of the water in the boiler.

7. A method according to any preceding claim, in which the step of monitoring the level of total dissolved solids in water in the boiler includes the step of measuring the conductivity of a sample of water in the boiler.

8. A method according to claim 7, in which the conductivity of the water is measured using pulses of electrical energy that are emitted only for a proportion of the time during which the conductivity measurement is being made.

9. A method according to claim 8, in which the pulses include both positive and negative pulses.

10. A method according to any of claims 7 to 9, in which the step of monitoring the level of total dissolved solids in water in the boiler includes the step of measuring the degree of polarisation of the sample of water whose conductivity is measured and taking the polarisation measurement into account in the assessment of the level of total dissolved solids.

11. A method according to any preceding claim, in which the step of monitoring the level of total dissolved solids in water contained in the boiler includes the step of removing a sample of water from the boiler.

12. A method according to claim 11, in which water is removed from the boiler and passed along a conduit through a water sampling probe assembly.

13. A method according to claim 12, in which the water sampling probe assembly receives surface blow down water from the pressurised steam boiler.

14. A method according to claim 12 or 13, in which water flow through the water sampling probe assembly is turbulent and effects a cleaning action on the water sampling probe assembly.

15.   A method according to any preceding claim, in which the assessment of the level of total dissolved solids is made having regard to the measurement of the pressure of steam in the boiler.

16.   A method according to any preceding claim, in which, when the indication of the level of total dissolved solids in the water contained in the boiler exceeds a predetermined maximum value, a boiler blow down sequence is commenced.

17.   A method according to any preceding claim, in which the level of total dissolved solids in the water contained in the boiler is monitored periodically.

18.   A pressurised steam boiler including:
       a boiler housing for containing water in a boiler,
       a burner for heating water in the boiler and converting the water into steam,
       a total dissolved solids detector for monitoring the level of total dissolved solids in the water in the boiler,
       a water level detector for monitoring the level of water in the boiler,
       a pressure detector for detecting the pressure of steam in the boiler,

a firing rate detector for detecting the firing
rate of the burner, and

a common control unit which receives input
signals from the total dissolved solids detector,
the water level detector, the pressure detector
and the firing rate detector, and is operative to
control the flow rate of water into the boiler,
blow down of the boiler and the firing rate of
the burner in dependence upon said input signals.

19.   A pressurised steam boiler according to claim
18, in which the control unit is arranged to control the
amount of blow down of the boiler according to the firing
rate of the burner.

20.   A pressurised steam boiler according to claim
19, in which the control unit is arranged to control the
amount of blow down of the boiler to be approximately
proportional to the firing rate of the burner.

21.   A pressurised steam boiler according to claim 19
or 20, in which the control unit is arranged to control the
amount of blow down of the boiler by altering the standard
time interval between blow downs.

22.   A pressurised steam boiler according to any of
claims 18 to 21, in which the control unit is arranged to
inhibit blow down of the boiler until the pressure of steam

measured by the pressure detector reaches a predetermined
level.

23. A pressurised steam boiler according to any of
claims 18 to 22, further including a temperature detector
for detecting the temperature of the water contained in the
boiler, the signal from the total dissolved solids detector
being arranged to be modified in dependence upon the
temperature measurement.

24. A pressurised steam boiler according to any of
claims 18 to 23, in which the total dissolved solids
detector comprises a conductivity detector for measuring
water conductivity.

25. A pressurised steam boiler according to claim 24,
in which the conductivity detector is arranged to emit
pulses of electrical energy only for a proportion of the
time during which the conductivity measurement is being
made.

26.   A pressurised steam boiler according to
claim 25, in which the pulses include both positive and
negative pulses.

27. A pressurised steam boiler according to any of
claims 24 to 26, further including a detector for measuring
the degree of polarisation of the water whose conductivity

is to be measured, the signal from the total dissolved
solids detector being arranged to be modified in dependence
upon the polarisation measurement.

5   28. A pressurised steam boiler according to any of
claims 18 to 27, in which the total dissolved solids
detector is arranged to monitor the level of total
dissolved solids in a sample of water in a water sampling
probe assembly connected to the interior of the boiler
10   housing by a conduit.

29. A pressurised steam boiler according to claim 28,
in which the water sampling probe assembly is arranged to
receive surface blow down water from the pressurised steam
15   boiler.

30. A pressurised steam boiler according to claim 28
or 29, in which the water flow through the water sampling
probe assembly is arranged to be turbulent and to effect a
20   cleaning action on the water sampling probe assembly.

31. A pressurised steam boiler according to any of
claims 18 to 30, in which the signal from the total
dissolved solids detector is arranged to be modified in
25   dependence upon the measurement of the pressure of the
steam in the boiler.

32. A pressurised steam boiler according to any of

claims 18 to 31, in which the boiler is controlled such that, when the indication of the level of total dissolved solids in the water in the boiler exceeds a predetermined maximum value, a boiler blow down sequence is commenced.

5

33. A pressurised steam boiler according to any of claims 18 to 32, in which the level of total dissolved solids of water contained in the boiler is arranged to be monitored periodically.

10

34. A method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the following steps:

    (a) measuring the conductivity of water contained in

15   the boiler,

    (b) measuring the temperature of water contained in the boiler, and

    (c) assessing the level of total dissolved solids in the water having regard to the results of the

20   conductivity and temperature measurements.

35. A method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the following steps:

    (a) measuring the conductivity of water contained in

25   the boiler, and

    (b) assessing the level of total dissolved solids having regard to the results of the conductivity measurement,

wherein the conductivity of the water is measured using pulses of electrical energy that are emitted only for a proportion of the time during which the conductivity measurement is being made.

36. A method according to claim 35, in which the pulses of electrical energy are emitted for less than 10% of the time during which the conductivity measurement is being made.

37. A method according to claim 35 or 36, in which the pulses include both positive and negative pulses.

38. A method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the following steps:
  (a) measuring the conductivity of water contained in the boiler,
  (b) measuring the degree of polarisation of the water whose conductivity is measured, and
  (c) assessing the level of total dissolved solids having regard to the conductivity and polarisation measurements.

39. A method of controlling the operation of a pressurised steam boiler heated by a burner, the method including the following steps:
  (a) providing a water sampling probe assembly for

measuring total dissolved solids, the probe

assembly being connected to receive water

contained in the boiler via a conduit,

(b)   passing water from the boiler through the water

5   sampling probe assembly, and

(c)   using the water sampling probe assembly to

measure the conductivity of the water passing

through the assembly,

wherein the water flow through the water sampling probe

10   assembly is turbulent and effects a cleaning action on the

water sampling assembly.

40.   A method according to any of claims 34 to 39,

further including any of the features claimed in any of

15   claims 1 to 33.

41.   A pressurised steam boiler including:

a boiler housing for containing water in a

boiler,

20   a burner for heating water in the boiler and

converting the water into steam,

a conductivity detector for measuring water

conductivity, and

a temperature detector for detecting the

25   temperature of the water contained in the boiler,

wherein the signal from the conductivity detector is

arranged to be modified in dependence upon the temperature

measurement to provide an indication of the total dissolved

solids in the water.

42. A pressurised steam boiler including:

a boiler housing for containing water in a

5   boiler,

a burner for heating water in the boiler and

converting the water into steam, and

a conductivity detector for measuring water

conductivity,

10 wherein the conductivity detector is arranged to emit

pulses of electrical energy only for a proportion of the

time during which the conductivity measurement is being

made.

15   43. A pressurised steam boiler according to claim 42,

in which the conductivity detector is arranged to emit

pulses of electrical energy only for less than 10% of the

time during which the conductivity measurement is being

made.

20

44. A pressurised steam boiler according to claims 42

or 43, in which the pulses include both positive and

negative pulses.

25   45. A pressurised steam boiler including:

a boiler housing for containing water in a

boiler,

a burner for heating water in the boiler and

converting the water into steam,

a conductivity detector for measuring water

conductivity, and

a polarisation detector for measuring the degree

5   of polarisation of the water whose conductivity

is to be measured,

wherein the signal from the conductivity detector is

arranged to be modified in dependence upon the polarisation

measurement to provide an indication of total dissolved

10   solids in the water.

46. A pressurised steam boiler including:

a boiler housing for containing water in a

boiler,

15   a burner for heating water in the boiler and

converting the water into steam, and

a water sampling probe assembly connected to the

interior of the boiler housing by a conduit for

measuring the total dissolved solids of water

20   contained in the boiler,

wherein the water flow through the water sampling probe

assembly is arranged to be turbulent and to effect a

cleaning action on the water sampling probe assembly.

Application No:	GB0415052.0	**Examiner:**	Ian Blackmore
Claims searched:	1-33	**Date of search:**	3 September 2004

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 & 18 at least	US2003/0226794 A (COKE) see whole document
X	1 & 18 at least	US6655322 B1 (GODWIN et al) see claims
A	-	GB2374135 A (AUTOFLAME) see description and claims

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W :

F4A

Worldwide search of patent documents classified in the following areas of the IPC^{07}

F22B; F22D

The following online and other databases have been used in the preparation of this search report

EPODOC, JAPIO, WPI