(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 121 437
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 84302239.3

(22) Date of filing: 02.04.84

(51) Int. Cl.³: F 23 N 5/00

(30) Priority: 31.03.83 GB 8308902

(43) Date of publication of application: 10.10.84 Bulletin 84/41

(84) Designated Contracting States: AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: MONARFLEX LIMITED
Lyon Way Hatfield Road
St. Albans, Herts.(GB)

(72) Inventor: Kelsall-Spurr, John Kenneth Francis
10 Northleach Drive Ainsdale
Southport Merseyside(GB)

(74) Representative: Valentine, Francis Anthony Brinsley et al,
REDDIE & GROSE 16 Theobalds Road
London WC1X 8PL(GB)

(54) **Control system for a boiler or furnace.**

(57) A control system for a boiler or furnace (2) extracts from the flue (4) a sample portion of the burnt flue gas. The level of unburnt oxygen therein is detected and compared with a stored reference level which, for the particular fuel supply rate, is indicative of efficient boiler or furnace operation. If the detected oxygen level differs from said stored reference level by more than a predetermined amount the relative proportion of fuel and air in the mixture is adjusted in the appropriate sense, prior to the burnt flue gas being re-tested. Before detection the sample portion is passed through a trap (18) having a condenser portion from which liquid condensed from the sample portion drains into a sump portion. The condensed liquid is automatically drawn from the sump portion at intervals by a siphonic duct.

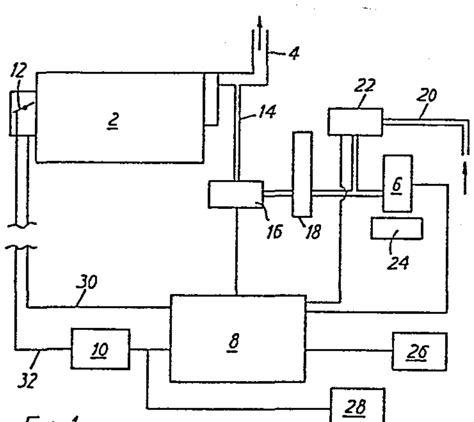

FIG. 1

EP 0 121 437 A2

Croydon Printing Company Ltd.

CONTROL SYSTEM FOR A BOILER OR FURNACE

This invention relates to a control system for a boiler or furnace of the type burning a fuel and air mixture and emitting a burnt flue gas. The invention has particular but not exclusive application to industrial boilers and furnaces.

According to the present invention there is provided a control system for a furnace or boiler of the type burning a fuel and air mixture and releasing a burnt flue gas, characterised by:

an oxygen sensor for generating a sensor signal representative of the proportion of unburnt oxygen in the burnt flue gas;

means for extracting from the burnt flue gas a sample portion and for delivering the sample portion to the oxygen sensor.

comparison means for comparing the sensor signal with a stored reference signal representative of a reference proportion of unburnt oxygen in the burnt flue gas when the furnace or boiler is operating efficiently, the comparison means being arranged to deliver an output signal when the sensor signal differs from the reference signal by more than a predetermined amount; and

means responsive to the output signal to adjust the relative proportion of fuel and air in the mixture to be burnt in the sense required for the proportion of unburnt oxygen in the flue gas to approach the reference proportion.

The control system thus uses the proportion of oxygen in the burnt flue gas to determine how efficiently the boiler or furnace is operating and causes corrective action to be taken if the operation is inefficient. A typical boiler will operate efficiently with about 2% unburnt oxygen in the burnt flue gas at a low fire, (that is, a low fuel supply rate), and about 4.5% at a high fire.

Preferably the control system includes a trap upstream of the oxygen sensor for removing liquid or vapour carried by the sample portion before the sample portion reaches the oxygen sensor. The liquid or vapour carried in the sample portion may be water vapour and/or liquid fuel mist. Particulate matter may also be removed from the sample portion in the trap. The control system may further comprise a heater to raise the temperature of the sample portion delivered to the oxygen sensor, to reduce condensation from the sample portion.

In a preferred embodiment the control system has storage means storing a further stored reference signal, representing a reference proportion of oxygen gas in ambient air, means for drawing ambient air alternatively to the sample portion into the oxygen sensor, and means for comparing the signal emitted by the sensor, representing a sensed proportion of oxygen gas in ambient air, with the further reference signal, to check the operative state of the oxygen sensor. If the oxygen sensor is found not to be functioning correctly the control system and/or furnace or boiler may be automatically shut down. Further, or in the alternative, a fault condition can be indicated, for example on a display unit, or audibly.

Preferably the control system, when used to control a boiler or furnace having valve means for adjusting the rate at which fuel is supplied to the boiler or furnace, further comprises means for determining said rate, storage means storing a range of reference signals representative of reference proportions of unburnt oxygen in the burnt flue gas when the boiler or furnace is operating efficiently, over the full range of rates at which fuel can be supplied thereto, and means for selecting from the stored range of reference signals the particular reference signal for a particular fuel supply rate determined, the particular reference signal being that compared with the sensor signal. In general, a boiler or furnace operating efficiently at low fuel supply rates should have less unburnt oxygen in the burnt flue gas than one operating efficiently at high fuel supply rates. With some boilers or furnaces the range of reference signals may be known and stored without reference to the particular boiler or furnace to be controlled but in most cases, particularly with industrial boilers or furnaces, tests will be run on the boiler or furnace to be controlled prior to commissioning, to determine the optimum proportions of unburnt oxygen in the burnt flue gas for particular fuel supply rates. These optimum proportions and the accompanying fuel supply rates can then be introduced into the storage means to serve as the reference signals.

The relative proportion of fuel and air in the mixture to be burnt is preferably adjusted by means of an air damper controlling the air intake to the boiler or furnace. However, when the boiler or furnace has a fuel valve this may be the adjustable part and a fixed air intake used.

The control system preferably includes means responsive to the output signal for assessing the movement of the adjustable part required for the proportion of unburnt oxygen in said flue gas to correspond to said reference proportion, a motor to move the adjustable part, control means whereby said motor moves the adjustable part by the assessed amount, and means operating following the stopping of said motor for comparing the new sensor signal with the reference signal and, if those signals vary by more than the predetermined amount, moving the adjustable part by a newly assessed amount.

According to a second aspect of the invention there is provided a method of controlling a boiler or furnace burning a fuel and air mixture and emitting a burnt flue gas, characterised by the steps of:

delivering a sample portion of the burnt flue gas to an oxygen sensor;

comparing the sensor signal with a stored reference signal representative of a reference proportion of unburnt oxygen in the burnt flue gas when the boiler or furnace is operating efficiently; and, if the sensor signal differs from the reference signal by more than a predetermined amount, adjusting the relative proportion of fuel and air in the mixture to be burnt in the sense required for the proportion of unburnt oxygen in the flue gas to approach the reference proportion.

Preferably the method includes the further steps of delaying for a predetermined interval after the relative proportion has been adjusted, comparing the new sensor signal with the reference signal, and if those signals differ by more than the predetermined amount, adjusting again the proportion of fuel and air in the mixture to be burnt in the appropriate sense. Furthermore the method may include the further step of assessing the movement of an adjustable part (fuel valve or air damper) required to bring said relative proportion of fuel and air in the mixture to be burnt to the reference proportion, operating a motor to move the adjustable part by the assessed amount, comparing the new sensor signal with the reference signal, and if those signals differ by more than the predetermined amount, moving the adjustable part by a newly assessed amount.

Preferably the method includes the further step of delivering at intervals ambient air to the oxygen sensor instead of burnt flue gas, and comparing the sensor signal with a further stored reference signal representing a further reference proportion, of oxygen gas in ambient air, to check the operative state of the oxygen sensor.

A sample portion is preferably extracted from the burnt flue gas and delivered to the oxygen sensor. The sample portion may be treated for the removal of liquid or vapour such as water vapour and oil mist before it reaches the oxygen sensor.

When a fuel supply valve is used the method will preferably include a preliminary step of introducing into a memory a range of reference signals representative of the proportion of unburnt oxygen in the burnt flue gas when the boiler is operating efficiently, over the full range of rates at which fuel can be supplied to a furnace or boiler and the step, during operation of the boiler or furnace, of measuring the particular fuel supply rate and accessing from the memory the stored reference signal corresponding thereto.

Again, the relation between unburnt oxygen and the rate at which fuel is supplied may be predetermined or, more commonly, determined by tests in situ on the boiler or furnace, prior to commissioning.

It is preferred to automatically execute the steps of comparing the sensor signal with the reference signal and, if necessary, adjusting the mixture on every change in the operating conditions of the boiler or furnace and at predetermined intervals during unchanging operation thereof.

According to a third aspect of the invention there is provided a trap for removing from a gas stream a liquid or vapour carried by the stream, characterised by:

a chamber formed by an upwardly elongate condenser portion to condense the liquid or vapour and a sump portion located beneath the condenser portion, to collect condensate, the sump portion having full and empty levels;

a gas inlet passage leading into the chamber;

a gas outlet passage from the condenser portion, the inlet and outlet passages communicating with the condenser portion adjacent opposite ends thereof;

and a siphonic duct forming a condensate outlet from the sump portion, a first end of the duct being located within the sump portion adjacent the empty level thereof and a second end of the duct being located outside the sump portion,the duct rising from its first end to a high point before dropping to its second end, the high point being at the level of the full level of the sump portion.

Preferably the gas inlet passage communicates with the chamber above the high point of the siphonic duct. The gas outlet passage may communicate with the condenser portion adjacent the upper end thereof and the gas inlet passage may communicate with the chamber at a lower position thereof, whereby gas rises from the inlet passage to the outlet passage to pass through the trap.

In a preferred embodiment the gas outlet passage is formed by ducting communicating with the condenser portion at the upper end thereof via an open upper end of the ducting, the ducting leaving the chamber at a position adjacent the lower end of the condenser portion.

The cross sectional area of the condenser portion is preferably larger than the cross sectional area of the inlet passage, so that gas flows more slowly in the condenser portion than in the inlet passage.

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

Fig. 1 is a block diagram schematically representing a control system according to the invention, controlling a boiler,

Fig. 2 shows a mechanical arrangement for moving an air damper of the boiler; and

Fig. 3 shows a trap through which burnt flue gas is passed;

Figs. 4a to 4h are flow charts showing the sequence of operations whereby the control system controls the boiler;

Fig. 1 shows a boiler (e.g. oil-fired) and a control system therefor. The burnt gas from the boiler passes along a flue 4 and this gas is analysed by the control system, which takes remedial action if the gas is found to denote inefficient operation of the boiler. To this end, particularly important parts of the control system are an oxygen sensing cell 6, a processing unit 8 comprising a microprocessor and associated memory stores, and a motor unit 10 to adjust the position of an air damper 12 of the boiler 2.

The oxygen sensing cell is of the type sold by City Technology Ltd of Sebastian Road, Islington, London, England or an equivalent cell, preferably one which can be used at ambient temperature.

Gas may be delivered to the oxygen sensing cell 6 by either of two routes. The first, for burnt flue gas, leads from the flue 4 along microbore tubing 14 (e.g. of stainless steel, copper or nylon). A pump 16, operating in response to a signal from the processing unit 8, draws burnt flue gas from the flue 4, along the tubing 14, through a trap 18 and thence to the cell 6.

The trap collects and ejects any particulate matter and has an automatic drain to discharge any surplus condensate. The trap is described in greater detail hereinafter.

The second route is for ambient air. Air is drawn along microbore tubing 20 by a pump 22 when it is desired to check that the cell 6 is working correctly. A non-return valve (not shown) having a spring loaded ball is incorporated in the tubing 20.

A transformer and heater unit 24 is fitted into the base of a chamber around the cell 6 to raise the temperature of the gas in the chmber by at least 7^{O}C, to reduce or prevent condensation.

Connection are made between the processing unit 8 and the pumps 16 and 22 and the cell 6, respectively.

The processing unit 8 includes a read-only memory (ROM) and a random-access memory (RAM). The ROM permanently stores the operating program corresponding to the flow chart of Fig. 3, the value of the proportion of free oxygen gas in ambient air, and information relating the proportion of unburnt oxygen in the burnt flue gas to fuel supply rate when the boiler is operating efficiently, for the full range of possible fuel supply rates to the boiler. The latter information is burnt into the ROM following tests on the boiler in situ, before the control system is used.

A numerical LED display unit 26 is connected to the processing unit 8 to display the numerical value for the proportion of oxygen in the gas being detected, or last detected, by the cell 6. The unit 26 can also display a fault condition. The unit is for mounting on the front of a cabinet (not shown) which houses most of the other parts of the control system. Also mounted on the front of the cabinet is a switching unit 28 to cause the damper 12 to open fully should the mains supply to the boiler or control system be interrupted.

The switching unit includes a rechargable NiCad battery kept under constant charge. The battery causes the damper to open fully whenever the mains supply is interrupted either by intention, for example on turning off the mains switch on the front of the cabinet or as a result of failure, for example of the mains electricity supply.

In Fig. 1 two lines are shown between the boiler 2 and the processing unit 8. One line 30 is a cable connected at the boiler end to a moving part of a fuel valve and at the microprocessor end to a potentometer (not shown) and analogue to digital converter, whereby a digital signal indicative of the fuel supply rate is delivered to the microprocessor. The other line 32 is a cable connected between the damper 12 and the motor unit 10. The motor unit 10 operates in response to a signal either from the processing unit 8 or from the switching unit 28.

The cables 30 and 32 may be Bowden or Teleflex-Morse cables. Other flexible cables for transmitting movement could also be used, as could more rigid mechanical linkages.

The movement of the fuel valve effects movement of the air damper directly in a relatively basic manner and the function of the control system is to superimpose on this basic movement of the air damper trimming movements to bring the boiler to more efficient operation.

Movement of the fuel valve directly causes movement of the damper through the agency of a cable 30. The arrangement shown in Fig. 2 is for superimposing onto the basic movement described above the calculated trimming movement to cause the damper to adopt the correct position for more efficient boiler operation.

The cable 32, which has relatively movable inner and outer parts, and which is caused to move in a relatively uncontrolled manner when the fuel valve moves, is gripped by an actuator 34 of the motor unit 10. The unit 10 uses a motor, the armature 36 of which is shown. The armature drives a belt 38 which passes over a pair of small rollers 40 and 42. Between the rollers the belt is connected to a lever 44 pivoted at its end 46 remote from the belt and clamped at an intermediate position to the outer sheath of the cable 32, by means of a cable grip 48. The cable grip is screwed to the lever on either side of the cable 32. For this purpose, the lever is drilled with a row of holes 50 and an adjacent pair are chosen having regard to whether the damper to be controlled requires to be moved a larger or a smaller amount as a result of a given movement of the motor.

This arrangment faithfully transmits calculated trimming movements from the stepping motor to the damper.

In another embodiment trimming movement is superimposed on the basic movement of the cable by a linear ram. The ram is moved back and forth by a motor in a direction generally along the cable.

The trap 18 shown in Fig. 3 has a chamber 52 formed by a sump portion 54 at the bottom and a columnar condenser portion 56 rising from the sump portion. Three ducts communicate with the interior of the chamber 52 and the chamber is otherwise enclosed. The three ducts are: a siphonic duct 58 serving as an outlet for condensed liquid from the sump portion 54; and a gas inlet duct 60 and a gas outlet duct 62 both communicating with the condenser portion. The inlet duct causes burnt flue gas to enter the condenser portion adjacent the lower end thereof. The outlet duct enters the chamber 52 at a low position and extends along the condenser portion to terminate adjacent the top of the condenser portion to communicate with said condenser portion via the open upper end 64 of the outlet duct.

The cross section of the inlet and outlet ducts is considerably smaller than the cross section of the condenser portion, along which gas must flow therebetween.

The siphonic duct 58 is a generally U-shaped tube and has one end 66 within the sump portion 54 just above the lowest part thereof and the other end 68 outside the sump portion, just below the height of the lowest part of the sump portion.

The high point of the siphonic duct, said high point being at the same level as, and determining, the highest level to which the condensate in the sump portion can rise, is lower than the position at which the gas inlet duct 60 communicates with the chamber. Thus, gas entering the chamber never has to bubble through collected condensate.

The operation of the device is as follows: burnt flue gas enters the condenser portion of the chamber at a low position thereof. Having just left the relatively narrow inlet duct 60 and entered the wider condenser tube it flows upwards slowly, towards the outlet duct 62. As it does so it passes over the inner surface of the wall of the condenser portion and the outer surface of the outlet duct. Water vapour and any oil mist in the burnt flue gas condenses on these surfaces, and in doing so may also tend to remove particulate matter from the gas stream. When the burnt flue gas reaches the top of the condenser portion it enters the narrow outlet duct and passes on to the oxygen sensing cell.

The liquid condensing within the condenser portion accumulates into droplets 70 which trickle down into the sump portion 54. When the level of condensate in the sump portion reaches the level of the top of the narrow siphonic duct 58 (as it is about to do in Fig.3) the condensate is siphoned out of the sump portion. Due to the position of the ends of the siphonic duct the sump portion will virtually empty and heavy particulate matter in the condensate will be discharged. The level of condensate in the sump portion will then rise again until it has reached the level at which the siphonic duct operates.

The duct 58 is sufficiently narrow, having regard to the rate at which condensate runs into the sump portion, to operate as a siphon rather than a simple overflow.

In a preferred embodiment the trap 18 is constructed from copper piping. The column 56 is 15mm o.d. piping and the various ducts 60, 62 and 58 are 6mm o.d. piping. The lower part of the chamber 52, which part largely forms the sump portion, is a Tee piece of 22mm o.d. The ends of the Tee piece, and the top of the column 56, are sealed by end caps.

The total height of the trap in this embodiment is 500mm and the high point of the siphon is 120mm from the empty level of the sump portion. In tests running against a back pressure of 6mm water gauge such a trap has been found to be well suited to gas sampling where up to 3 litres/minute of gas were being pumped through into a electro-chemical cell for analysis. Larger or small units can of course be constructed for different applications.

It is necessary on start up to fill the chamber to its discharge level otherwise gas could go direct to the siphonic duct 58.

As the trap is entirely automatic in operation and self cleansing it requires virtually no maintenance.

It will be appreciated that the temperature of the condenser portion should be kept below the dew-point of the gas. Depending on the circumstances, it may be necessary to provide cooling means whereby this is arranged.

It will be appreciated that if it is desired to subject the burnt flue gas to a scrubbing effect, the inlet duct 60 could enter the chamber at a lower position to that described above, such that the gas would have to bubble through condensate and up into the condensor portion.

The operation of the control system may be summarised as follows. When the boiler or furnace starts up the control system immediately begins to operate. Its first main function is to open the damper fully. It then checks the correct functioning of the oxygen sensing cell 6 by operating pump 22 to draw in ambient air. The sensed proportion of oxygen in the air is compared with a stored value of 20.9%. If the cell is functioning correctly the system tests for the proportion of unburnt oxygen in the flue gas. Thus, pump 22 is stopped and pump 16 started. Burnt flue gas is drawn from the flue stack and passes through the trap 18 to the cell 6, where it is heated, to prevent water vapour condensing in the cell, by heater 24. After a delay period, typically of 20 seconds, the oxygen percentage level is ascertained and compared with a reference level which has been selected from the stored values as a result of a signal delivered to the processing unit 8 indicating the fuel valve position. If the comparison reveals that the oxygen level is too high or too low the microprocessor calculates the adjustment to be made in the position of the damper, which is duly adjusted. The microprocessor now waits for the damper adjustment to take effect (waiting typically 20 to 45 seconds) and the sequence is repeated, until the unburnt oxygen level in the flue gas is within a predetermined range about the reference level. We have found that the number of sequences needed for the unburnt oxygen level to be within the preset range will not normally exceed four.

After a sample portion has been drawn which indicates that the unburnt oxygen level is within the preset range (or, if preferred, after two successive sample portions have been drawn with both indicating that the oxygen level is within the range), the microprocessor goes into a 'snooze' mode and will take no further action until either the fuel supply rate changes, or until a predetermined interval has elapsed. The latter could for example be 2 hours. The microprocessor thus runs a self-check sequence at predetermined intervals during unchanging operation of the boiler. This involves checking the cell operation by drawing in ambient air.

Should the cell check ever indicate that the cell is no longer operating accurately the damper is fully opened, the control system is shut down and the display unit 26 displays the legend 'FAULT CONDITION'. The display unit is also used to automatically display the last percentage value of oxygen detected, either in the sample portion of the burnt flue gas or in ambient air. Furthermore the user may operate a switch to display on the control unit the reference level, or set point, of unburnt oxygen for the fuel supply rate.

The flow charts of Figs. 4 set out in detail the steps by which the operations described above executed. In Fig. 4a, the operations shown include reading from the ROM information relating to the optimum proportion of unburnt oxygen in the flue gas for various supply rates (or a proportionality constant therebetween should the relationship be linear) and the various times at which different operations should be executed.

This information is stored in the RAM. An initial oxygen set point is set in accordance with the fuel supply rate and the motor unit then moves the damper to its fully open position. The programme then enters a calibration subroutine (indicated in Fig. 4b and set out more fully as Fig. 4e) to check the correct operation of the cell 6, as previously described, and then a control loop which involves: pumping burnt flue gas to the cell 6 and, after a predetermined interval, determining the proportion of oxygen therein (see the read stack sub-routine of Fig. 4f); periodically checking whether or not the fuel supply rate has changed by reading the fuel valve position and comparing it with the previous position (see the modulation check sub-routine of Fig. 4g); displaying the measured oxygen concentration, deciding whether it is within a predetermined pass band around a stored signal for the particular fuel supply rate and calculating the required damper correction if it is not within the pass band; operating the motor unit 10 to move the damper by the calculated amount; waiting a predetermined interval and further checking that the fuel valve position has not changed (Fig. 4c); re-entering the read stack sub-routine; and repeating operations until the oxygen concentration in the flue gas is within the pass band. The program then exists from the control loop and enters a snooze loop. The snooze loop is left when the fuel valve position changes, the control loop being re-entered if the position has been changed. The control loop is moreover re-entered after a predetermined interval of unchanging boiler or furnace operation. At set intervals during the snooze period the calibration loop is re-entered to check the cell operation.

The clock interrupt sub-routine on Fig. 4h shows how a clock timer interrupting the microprocessor is used to control the incrementing of the calibration and snooze counters and the decrementing of time out counters.

Although the embodiment described is of a control system which adjusts a damper to regulate the relative proportion of fuel and air in a mixture to be burnt it will be apparent that a system according to the invention could adjust a fuel valve, in conjunction with an air damper or with a fixed air intake.

CLAIMS

1. A control system for a furnace or boiler (2) of the type burning a fuel and air mixture and releasing a burnt flue gas, characterised by:

an oxygen sensor (6) for generating a sensor signal representative of the proportion of unburnt oxygen in the burnt flue gas;

means (16) for extracting from the burnt flue gas a sample portion and for delivering the sample portion to the oxygen sensor;

comparison means (8) for comparing the sensor signal with a stored reference signal representative of a reference proportion of unburnt oxygen in the burnt flue gas when the furnace or boiler is operating efficiently, the comparison means being arranged to deliver an output signal when the sensor signal differs from the reference signal by more than a predetermined amount; and

means (10) responsive to the output signal to adjust the relative proportion of fuel and air in the mixture to be burnt in the sense required for the proportion of unburnt oxygen in the flue gas to approach the reference proportion.

2. A control system according to claim 1, further characterised by storage means (8) storing a further stored reference signal, representing a reference proportion of oxygen gas in ambient air, means (22) for drawing ambient air alternatively to the sample portion into the oxygen sensor, and means for comparing the signal emitted by the sensor, representing a sensed proportion of oxygen gas in ambient air, with the further reference signal, to check the operative state of the oxygen sensor.

3. A control system according to claim 1 or 2, for a boiler or furnace having valve means for adjusting the rate at which fuel is supplied to the boiler or furnace, further characterised by means for determining said rate, storage means (8) storing a range of reference signals representative of reference proportions of unburnt oxygen in the burnt flue gas when the boiler or furnace is operating efficiently, over the full range of rates at which fuel can be supplied thereto, and means (8) for selecting from the stored range of reference signals the particular reference signal for a particular fuel supply rate determined, the particular reference signal being that compared with the sensor signal.

4. A control system according to any preceding claim, for a boiler or furnace having an air damper (12), the control system comprising means responsive to the output signal for assessing the movement of the damper required for the proportion of unburnt oxygen in the flue gas to correspond to the reference proportion, a damper operating motor (10) to move the damper, motor control means whereby the motor moves the damper by the assessed amount, and means operating following the stopping of the motor for comparing the new sensor signal with the reference signal and, if those signals vary by more than the predetermined amount, moving the damper by a newly assessed amount.

5. A method of controlling a boiler or furnace (2) burning a fuel and air mixture and emitting a burnt flue gas, characterised by steps of:

delivering a sample portion of the burnt flue gas to an oxygen sensor (6);

comparing the sensor signal with a stored reference signal representative of a reference proportion of unburnt oxygen in the burnt flue gas when the boiler or furnace is operating efficiently; and, if the sensor signal differs from the reference signal by more than a predetermined amount, adjusting the relative proportion of fuel and air in the mixture to be burnt in the sense required for the proportion of unburnt oxygen in the flue gas to approach the reference proportion.

6. A method according to claim 5, further characterised by the step of delivering at intervals ambient air to the oxygen sensor instead of the burnt flue gas, and comparing the sensor signal with a further stored reference signal representing a further reference proportion, of oxygen gas in ambient air, to check the operative state of the oxygen sensor.

7. A method according to claim 5 or 6, further characterised by the preliminary step of introducing into a memory (8) a range of reference signals representative of the proportion of unburnt oxygen in the burnt flue gas when the boiler is operating efficiently, over the full range of rates at which fuel can be supplied to a furnace or boiler and the step, during operation of the boiler or furnace, of measuring the particular fuel supply rate and accessing from the memory the stored reference signal corresponding thereto.

8. A method according to claim 7, wherein the steps of comparing the sensor signal with the reference signal and, if necessary, adjusting the mixture, are automatically executed on every change in the operating conditions of the boiler or furnace and at predetermined intervals during unchanging operation thereof.

9. A trap (18) for removing from a gas stream a liquid or vapour carried by the stream, characterised by:

a chamber (52) formed by an upwardly elongate condenser portion (56) to condense the liquid or vapour and a sump portion (54) located beneath the condenser portion, to collect condensate, the sump portion having full and empty levels;

a gas inlet passage (60) leading into the chamber;

a gas outlet passage (62) from the condenser portion, the inlet and outlet passages communicating with the condenser portion adjacent opposite ends thereof;

and a siphonic duct (58) forming a condensate outlet from the sump portion, a first end of the duct being located within the sump portion adjacent the empty level thereof and a second end of the duct being located outside the sump portion, the duct rising from its first end to a high point before dropping to its second end, the high point being at the level of the full level of the sump portion.

10. A trap according to claim 9 wherein the cross sectional area of the condenser portion is larger than the cross sectional area of the inlet passage.

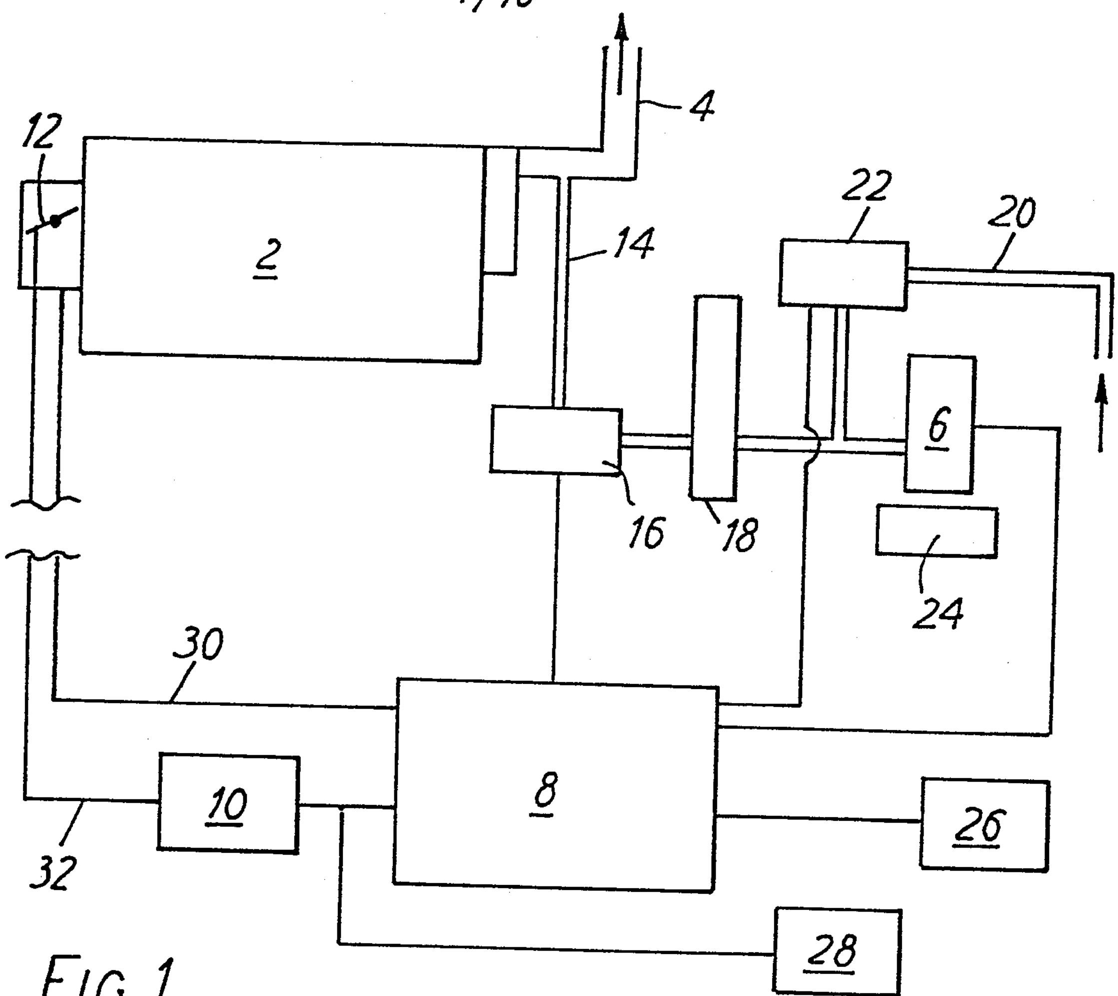

FIG.1

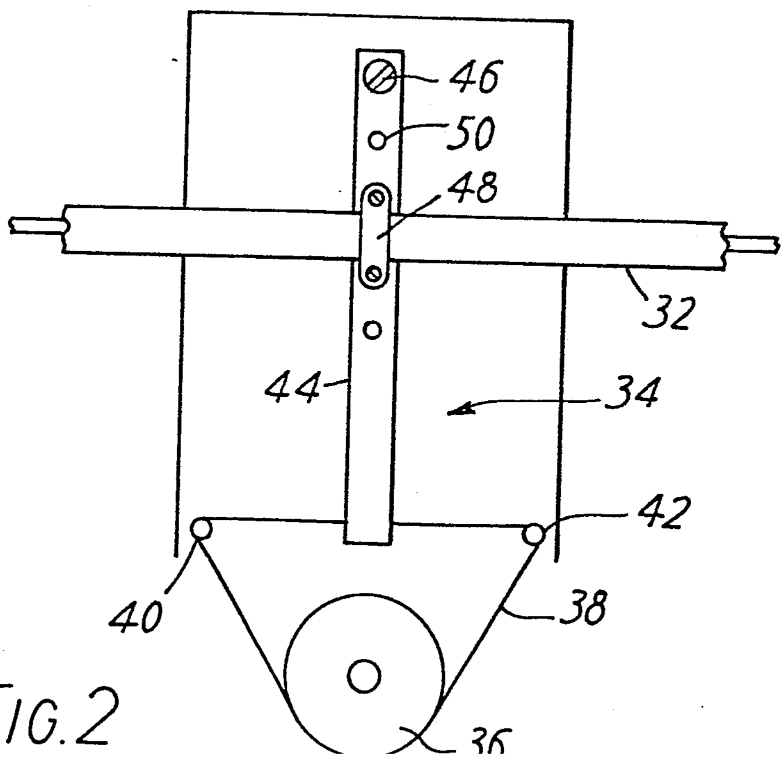

FIG.2

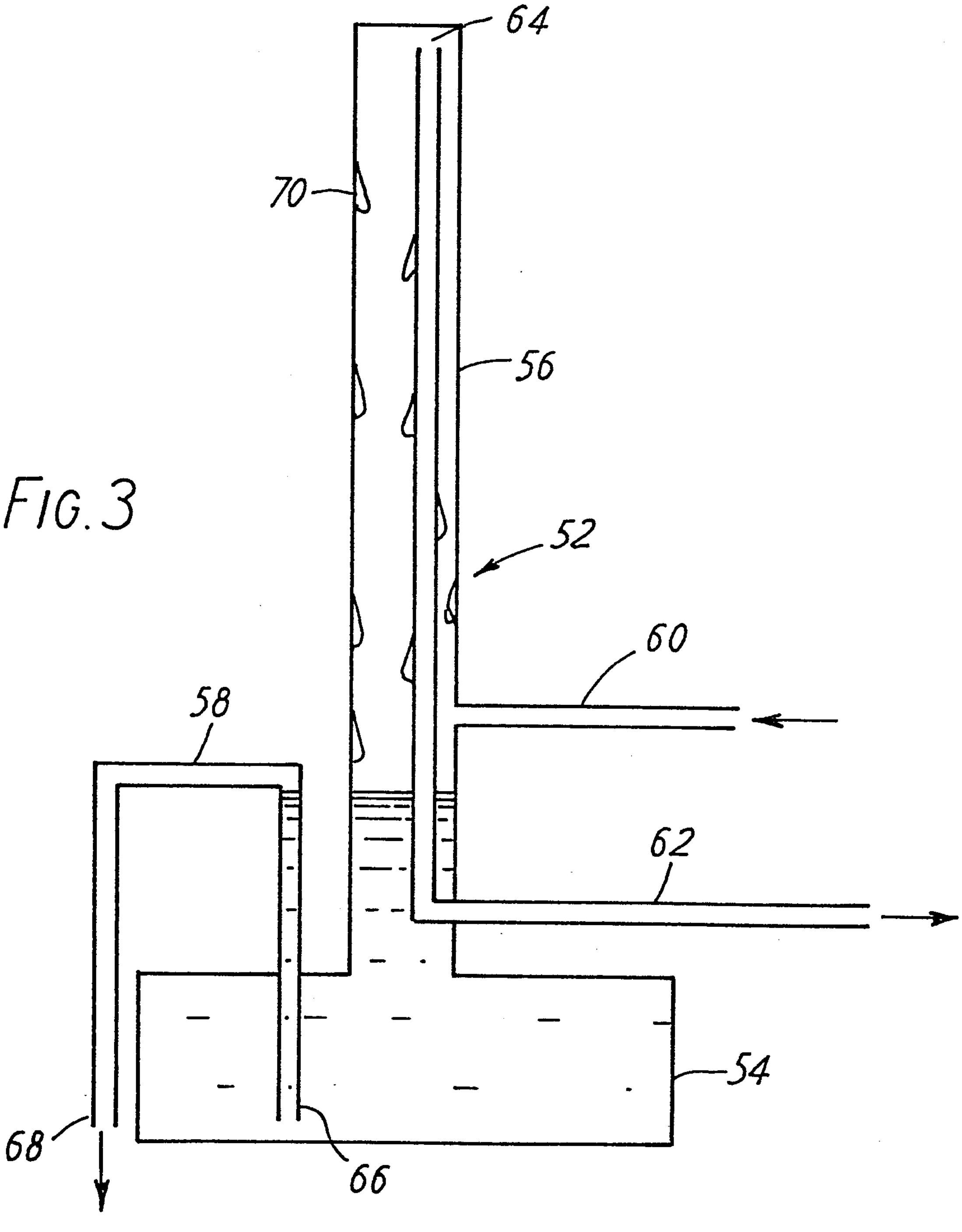

FIG. 3

PROGRAMME FLOW CHART FOR CONTROL SYSTEM

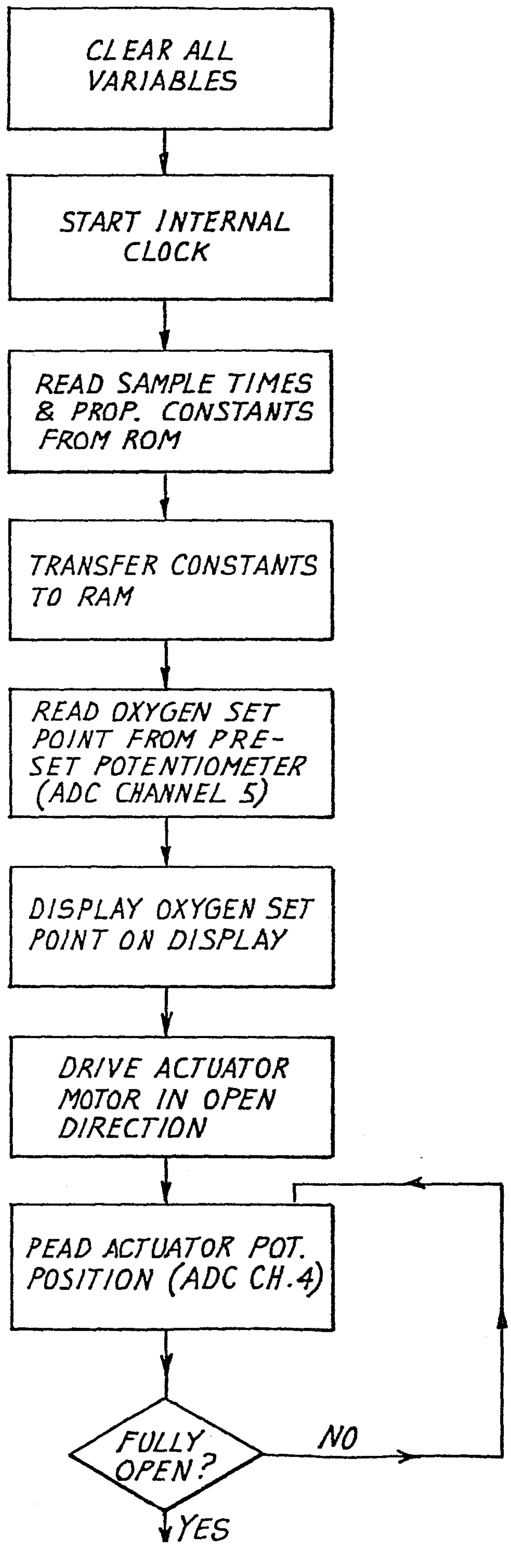

FIG.4a

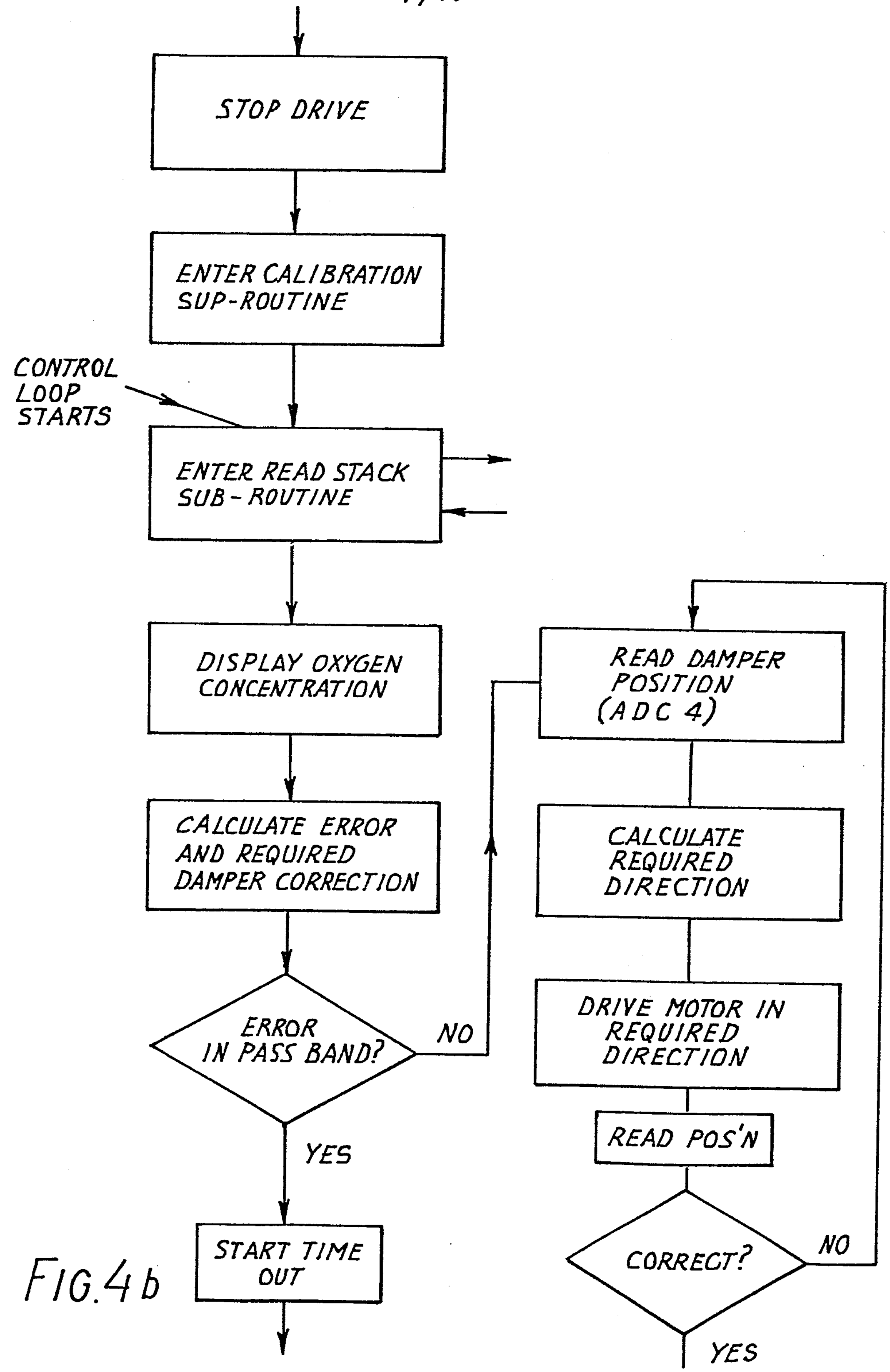
STOP DRIVE
ENTER CALIBRATION SUP-ROUTINE
CONTROL LOOP STARTS
ENTER READ STACK SUB-ROUTINE
DISPLAY OXYGEN CONCENTRATION
CALCULATE ERROR AND REQUIRED DAMPER CORRECTION
ERROR IN PASS BAND?
NO
YES
START TIME OUT
READ DAMPER POSITION (ADC 4)
CALCULATE REQUIRED DIRECTION
DRIVE MOTOR IN REQUIRED DIRECTION
READ POS'N
CORRECT?
NO
YES

FIG.4b

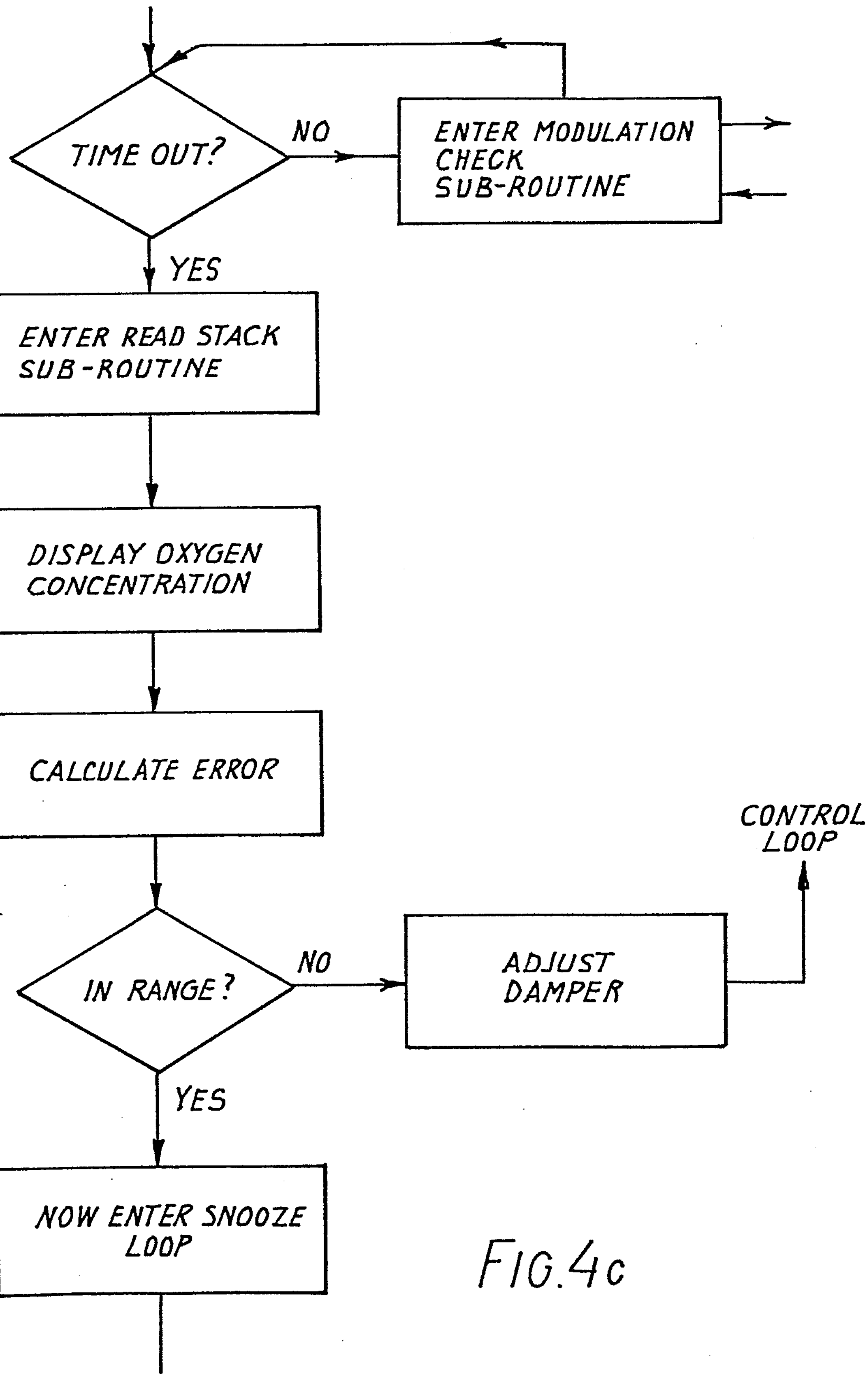
TIME OUT?
NO
ENTER MODULATION CHECK SUB-ROUTINE
YES
ENTER READ STACK SUB-ROUTINE
DISPLAY OXYGEN CONCENTRATION
CALCULATE ERROR
CONTROL LOOP
IN RANGE?
NO
ADJUST DAMPER
YES
NOW ENTER SNOOZE LOOP

FIG.4c

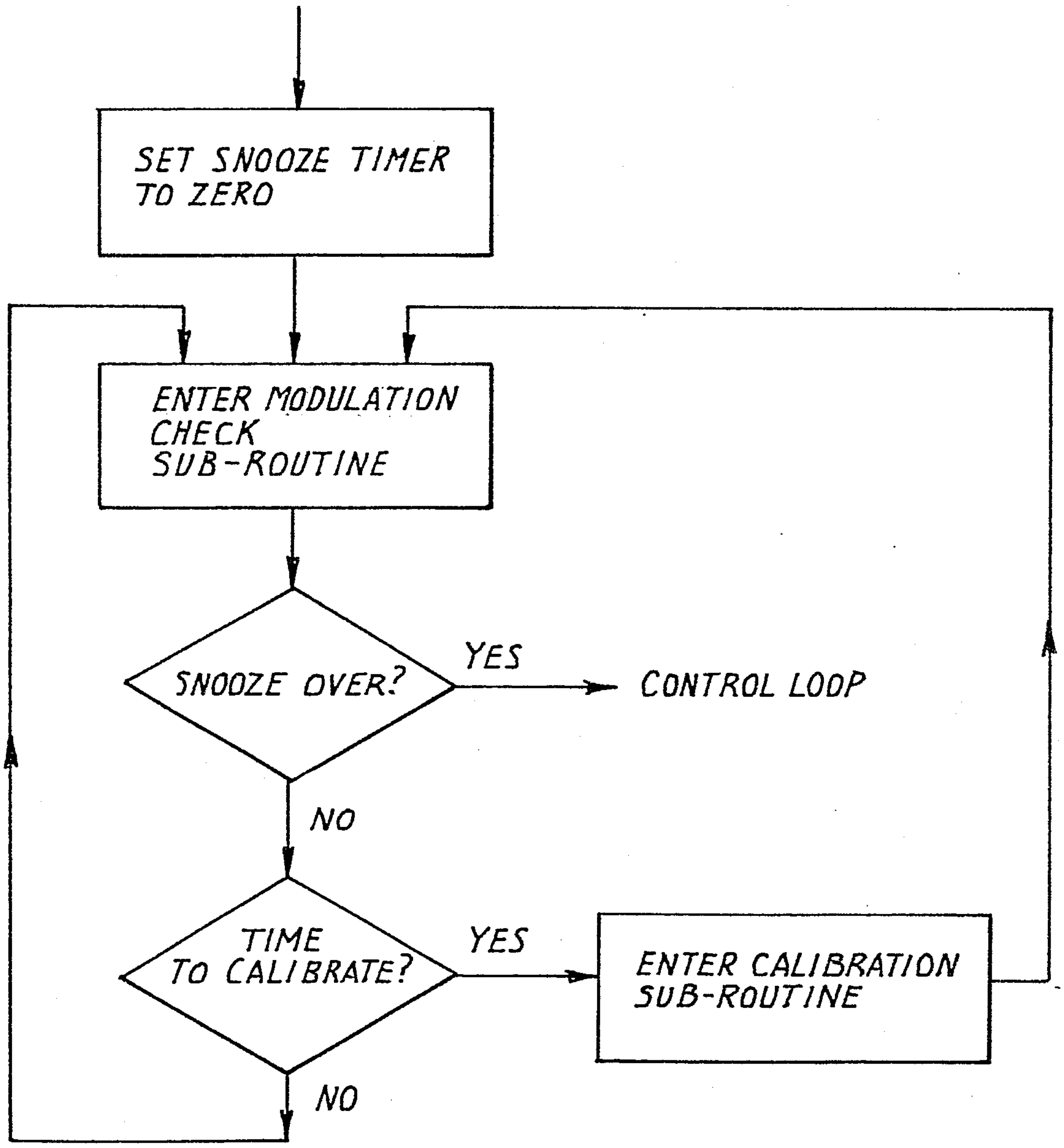
SET SNOOZE TIMER
TO ZERO
ENTER MODULATION
CHECK
SUB-ROUTINE
SNOOZE OVER?
YES
CONTROL LOOP
NO
TIME
TO CALIBRATE?
YES
ENTER CALIBRATION
SUB-ROUTINE
NO

FIG. 4d

CALIBRATION SUB-ROUTINE

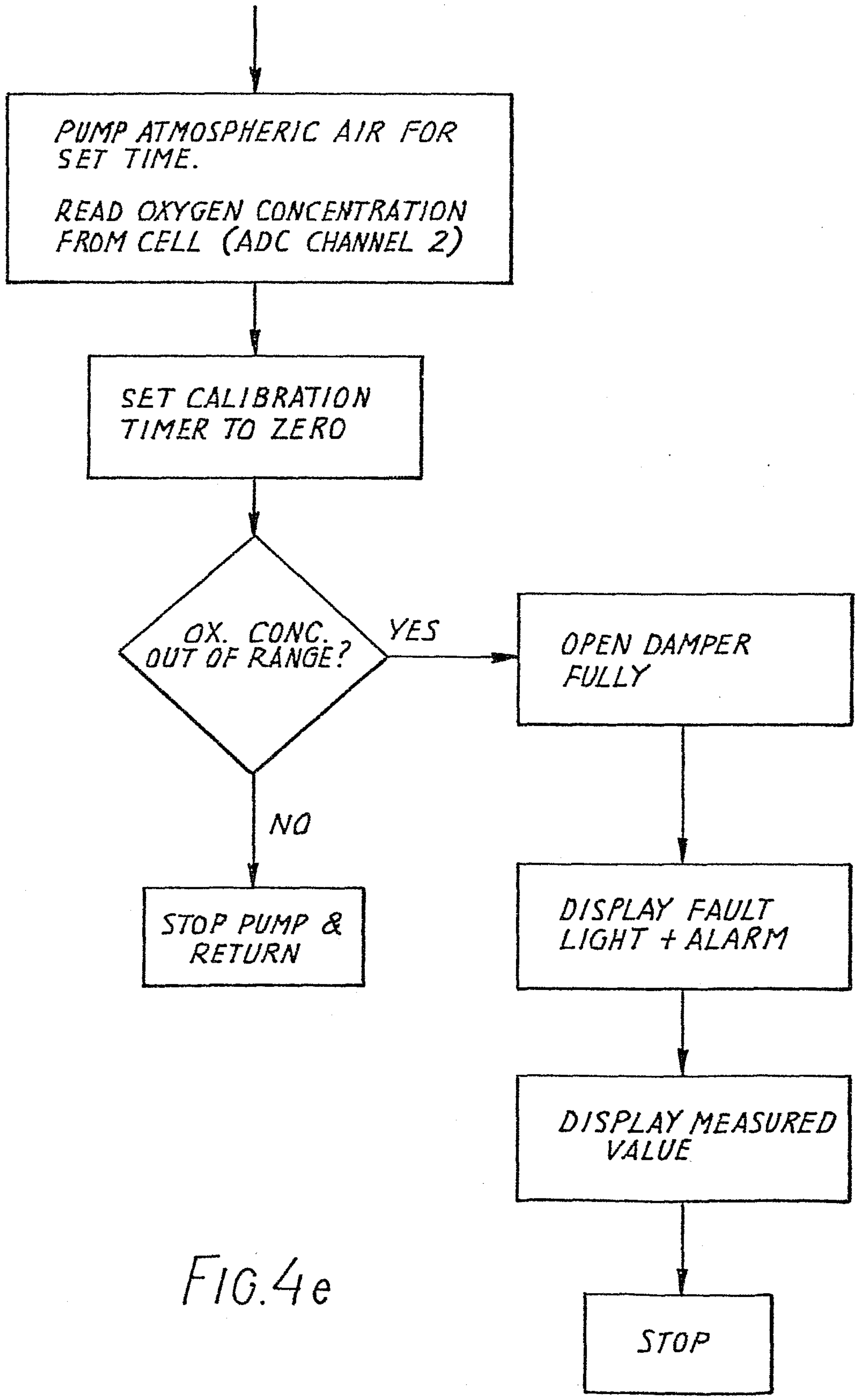

FIG.4e

READ STACK SUB-ROUTINE

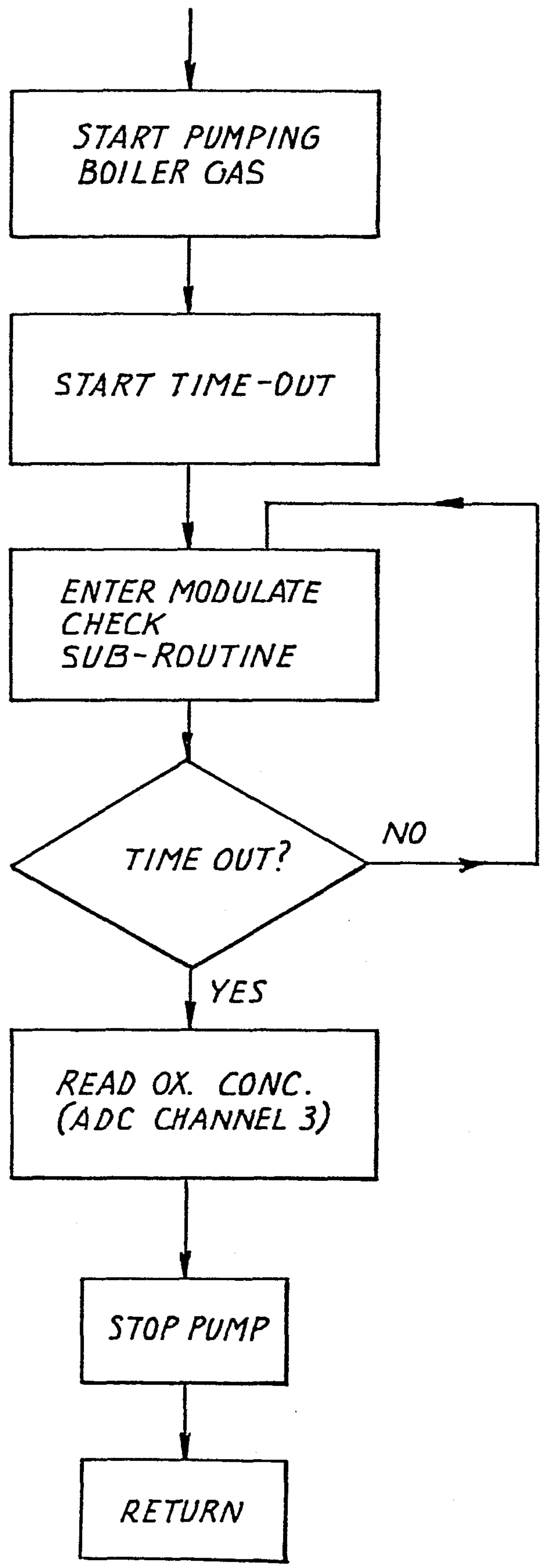

FIG.4f

MODULATION CHECK SUB-ROUTINE

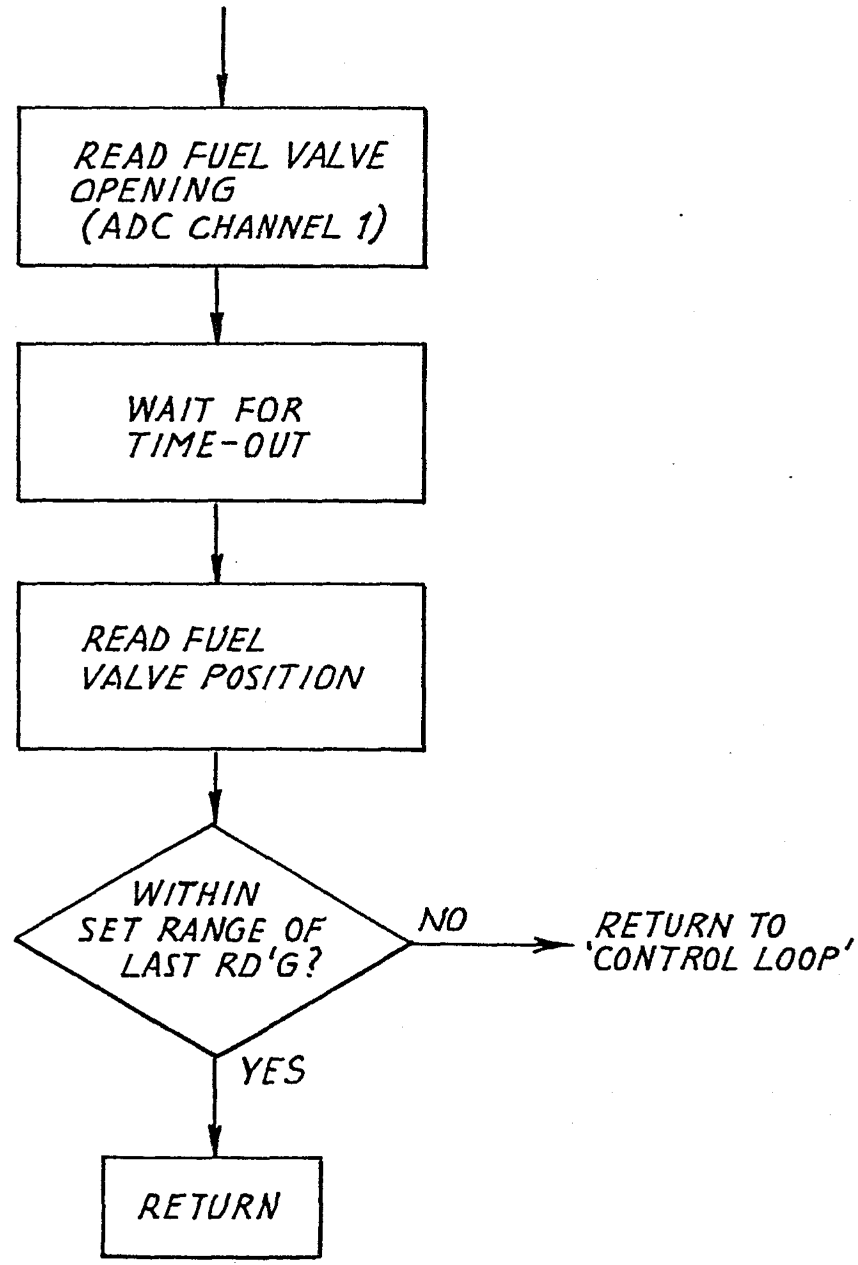

FIG.4g

CLOCK INTERRUPT SUB-ROUTINE

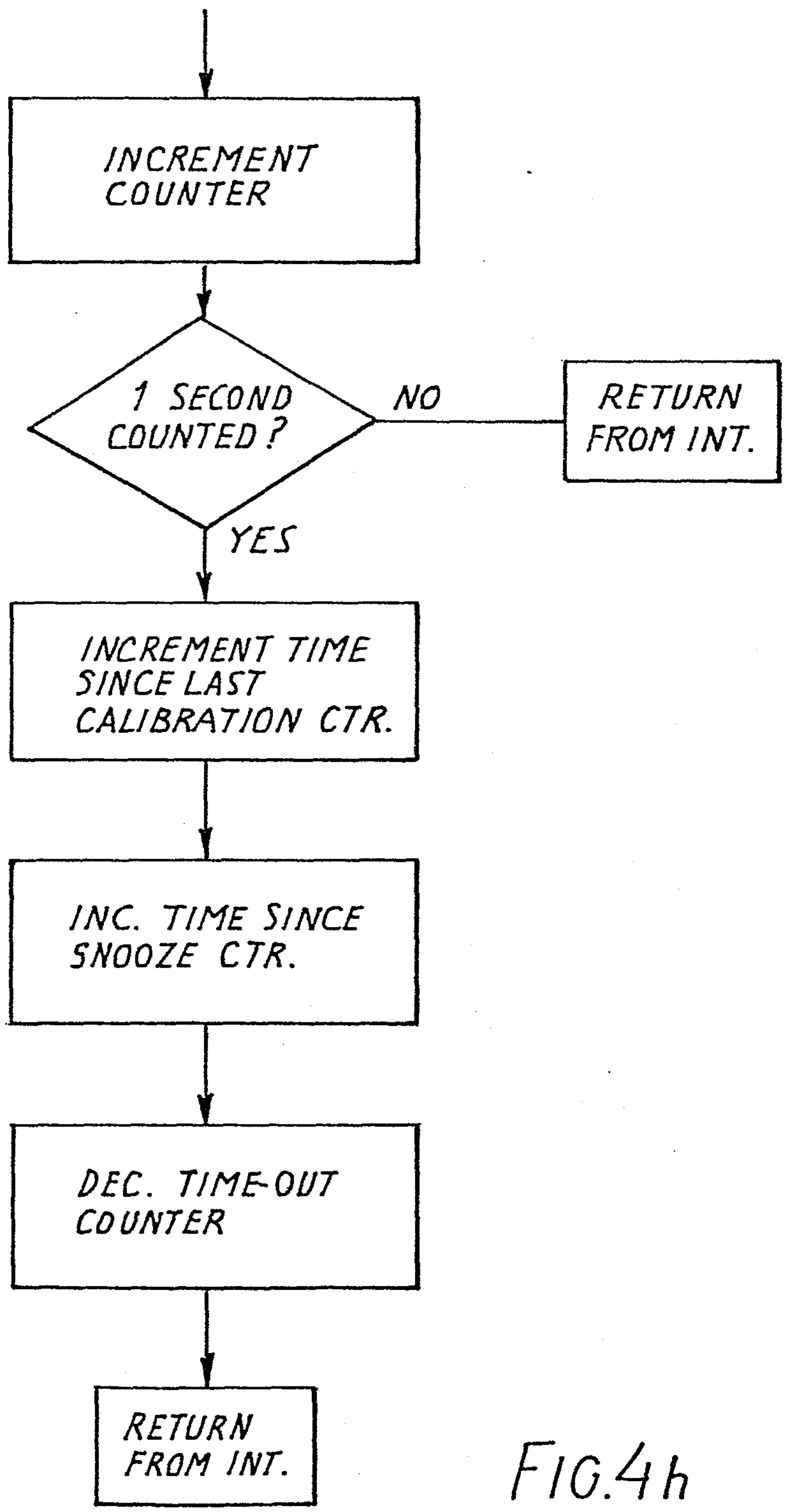

FIG.4h