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(54) **Electronically controlled woodburning stove**

(57) Method for controlling a woodburning stove and an electronic control (38) for a woodburning stove (2) of the type including a combustion chamber (6) which is downwards separated from an ash chamber (18) by means of a grate bottom (12) and having a walling (8) at the rear and at both sides, which upwards has an inclining forwards/upwards extending wall part (22), the combustion chamber (6) upwards, preferably via a reversing plate (24), being connected with a chimney (28) via a flue gas exhaust (26), the control including a thermal sensor (46) and a A-probe (48) provided in the flue gas exhaust (26), wherein the control (38) is incorporated in a cabinet (36) which is adapted to be disposed below the ash chamber (18) and which includes a common air intake (48) and one or more regulating valves (34, 40, 42) with a damper plate, each drivingly connected with an electric motor (50, 52, 54) arranged in the cabinet, the motor being control connected with the electronic control (38), the regulating valve or valves (34, 40, 42) interacting with air ducts for supplying primary and secondary combustion air (19, 33, 45), the air ducts being disposed side by side at a rear side of the woodburning stove (2).

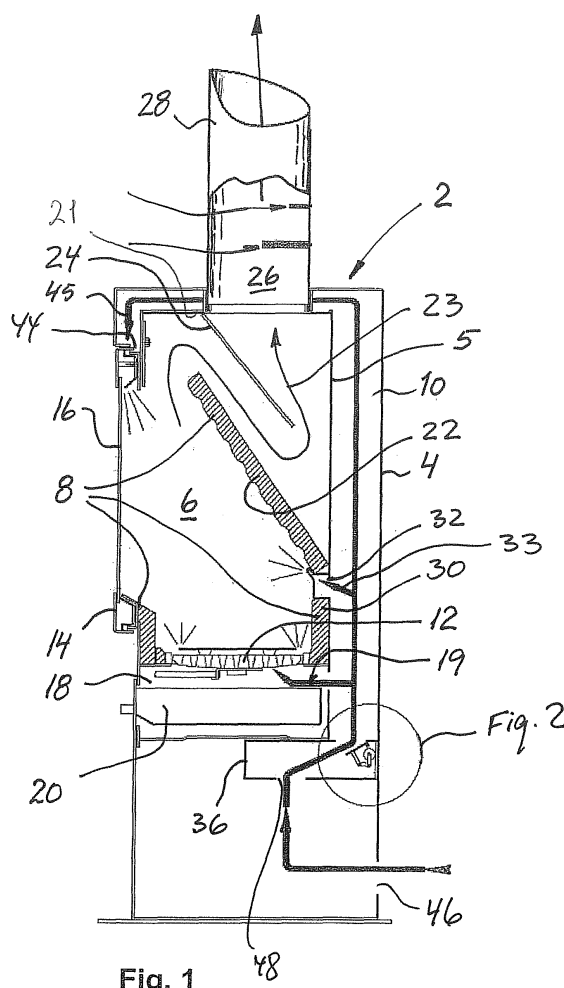


Fig. 1

Fig. 2

Description

Field of the Invention

[0001] The present invention relates to a method for controlling a woodburning stove and of the kind stated in the preamble of claim 1.

[0002] The invention furthermore concerns an electronic control for a woodburning stove and of the kind indicated in the preamble of claim 2.

[0003] The invention additionally concerns a woodburning stove of the kind indicated in the preamble of claim 6 with an electronic control according to the invention.

Background of the Invention

[0004] Modern woodburning stoves are often designed as a stove for firing with wood, coal, coke, briquettes or wood pellets as the stove includes mechanical control means for regulating supply of primary as well as secondary combustion air. Primary combustion air is supplied through the grate, i.e. up through the fuel, while secondary combustion air is supplied directly to the combustion chamber of the stove in order to ensure combustion of the gasses developed in the combustion chamber.

[0005] DK 166 637 B1 discloses a woodburning stove of this type and where the control means include a thermal sensor disposed in the flue gas exhaust and controlled valve means connected therewith for controlling supply of primary and secondary combustion air to the combustion chamber. The valve means are found at the back side of the stove in a separate wall part including valve openings that are connected with the ash chamber and an upper part of the combustion chamber and which are provided with the said sensor. The valve means include damper plates that are adapted to be displaced relative to the valve openings and which also are control connected with operating arms arranged from operation from the front side of the stove, and valve plates adapted to be displaced in relation to the damper plates and which are mechanically control connected with the sensor. The damper and valve plates are designed and mutually suspended in relation to the valve openings such that respective valve openings can be forcibly opened by forced control of the valve plates, and that the damper and valve plates for the secondary combustion air are designed and mutually suspended in relation to the valve opening such that it cannot be forcibly closed when the woodburning stove is hot, i.e. within the operating range of the sensor.

[0006] DK 1998 00198 U3 discloses a woodburning stove where the combustion with the intention of ensuring optimal environmental and economical combustion includes an electronic control of primary and secondary air supply. At the same time, the development concerns a woodburning stove where the door of the stove can be opened electronically and/or manually such that the

woodburning stove can be used both as an open and as a closed fireplace. This double function requires a separate regulation of the combustion air, why the opening/closing function interacts with the electronic control of the combustion air supply.

Object of the Invention

[0007] On this background, the purpose of the invention is to indicate a new and improved method for controlling a woodburning stove and an electronic control for a woodburning stove of the kind specified in the introduction, and which enables achieving a woodburning stove with a more correct combustion and at the same time a more environmentally optimal combustion such that the utilisation of the fuel of the stove is further optimised simultaneously.

Description of the Invention

[0008] The method according to the invention is **characterised in that** tertiary combustion air is supplied directly to the combustion chamber via a feed opening along a top side of the door, and that supply of primary, secondary and tertiary combustion air to the combustion chamber is controlled by the electronic control by means of separate control valves.

[0009] By means of simple measures it hereby becomes possible to achieve a woodburning stove with a more correct combustion and at the same time a more environmentally optimal combustion, such that the utilisation of the fuel by the stove is further optimised at the same time.

[0010] In other words, a high utility value is attained due to the automatic control which, in contrast to manual control of supply of respective quantities of primary, secondary and tertiary combustion air, can be optimised in a simple way by the automatic control.

[0011] The invention also concerns an electronic control which is **characterised in that** the control is incorporated in a cabinet which is adapted to be disposed below the ash chamber and which includes a common air intake and one or more air valves with a damper plate, each drivingly connected with an electric motor arranged in the cabinet, the motor being control connected with the electronic control, the air valve or valves interacting with air ducts for supplying primary and secondary combustion air, the air ducts being disposed side by side at a rear side of the woodburning stove.

[0012] The electronic control according to the invention is suitably designed such that the cabinet includes three air valves, namely a first air valve interacting with a first air duct for supplying primary combustion air, a second air valve interacting with a second air duct for supplying secondary combustion air, and a third air valve interacting with a third air duct for supplying tertiary combustion air.

[0013] The control according to the invention may ad-

vantageously be designed such that the first air duct opens into the ash chamber above a possible ash pan, as primary combustion air is supplied to the combustion chamber through the grate bottom, and that the second air duct opens in the rear side of the combustion chamber spaced apart from the grate bottom, as secondary combustion air is supplied through a horizontal slotted opening at the transition to the inclining wall part of the combustion chamber.

[0014] It may furthermore be advantageous that the electronic control according to the invention is designed such that the third air duct opens into a horizontal slotted opening along the top side of a glass door at the front side of the combustion chamber, as tertiary combustion air, besides being mixed with rising gasses, is also used as scavenging air for keeping clean the inner side of the glass door.

[0015] The invention additionally concerns a woodburning stove including a combustion chamber which is downwards separated from an ash chamber by means of a grate bottom and having a walling at the rear and at both sides which upwards has an inclining forwards/upwards extending wall part, the combustion chamber upwards preferably via a reversing plate being connected with a chimney via a flue gas exhaust, the woodburning stove including an electronic control which includes a thermal sensor and a λ -probe provided in the flue gas exhaust, the woodburning stove being **characterised in that** the control is incorporated in a cabinet which is adapted to be disposed below the ash chamber and which includes a common air intake and one or more air valves with a damper plate, each drivingly connected with an electric motor arranged in the cabinet, the motor being control connected with the electronic control, the air valve or valves interacting with air ducts for supplying primary and secondary combustion air, the air ducts being disposed side by side at a rear side of the woodburning stove.

[0016] The woodburning stove according to the invention is suitably designed such that the cabinet includes three air valves, namely a first air valve interacting with a first air duct for supplying primary combustion air, a second air valve interacting with a second air duct for supplying secondary combustion air, and a third air valve interacting with a third air duct for supplying tertiary combustion air.

[0017] The woodburning stove according to the invention is designed in a way known per se such that the first air duct opens into the ash chamber above a possible ash pan, as primary combustion air is supplied to the combustion chamber through the grate bottom, and that the second air duct opens in the rear side of the combustion chamber spaced apart from the grate bottom, as secondary combustion air is supplied through a horizontal slotted opening at the transition to the inclining wall part of the combustion chamber.

[0018] With the intention of further optimising the woodburning stove according to the invention, it may be

suitably designed such that the third air duct opens into a horizontal slotted opening along the top side of a glass door at the front side of the combustion chamber, as tertiary combustion air, besides being mixed with rising gasses, is also used as scavenging air for keeping clean the inner side of the glass door.

Description of the Drawing

[0019] The invention is explained in more detail in the following with reference to the drawing in which:

- Fig. 1 shows a plan view of an embodiment of a woodburning stove with electronic control according to the invention, as seen from the side;
- Fig. 2 shows an enlarged plan view of a detail of a control valve in a woodburning stove according to the invention;
- Fig. 3 shows a plan view of an embodiment of a mounting plate for a cabinet for an electronic control according to the invention;
- Fig. 4 shows a curve illustrating flue gas temperature per time unit;
- Fig. 5 shows a curve illustrating the CO-content in the flue gas per time unit;
- Fig. 6 shows a curve illustrating valve opening in % for the supply of primary combustion air per time unit;
- Fig. 7 shows a curve illustrating valve opening in % for the supply of secondary combustion air per time unit;
- Fig. 8 shows a curve illustrating valve opening in % for the supply of tertiary combustion air per time unit;
- Fig. 9 shows a perspective view of a preferred embodiment of a valve cabinet for a woodburning stove according to the invention;
- Fig. 10 shows a perspective view of the valve cabinet shown in Fig. 9, as seen from an open underside;
- Fig. 11 shows a perspective view of the valve cabinet shown in Fig. 9, shown with completely open valve for primary air and partially open valve for secondary combustion air;
- Fig. 12 shows a perspective view, partly in section, of a rearmost part of the valve cabinet shown in Fig. 9; and

Fig. 13 shows a view of a laboratory version of the regulating valves for an electronic control according to the invention.

Detailed Description of the Invention

[0020] The woodburning stove 2 shown in Fig. 1 is constructed of steel plate as a conventional convection oven with an external casing 4 and a combustion chamber 6 which is internally covered by a heat-resistant material 8 (walling), and which in a known way enclosed by a convection channel system 10, e.g. with inlet holes for cold air at the bottom of the casing 4 and with (not shown) discharge holes for heated air at the top of the casing 4.

[0021] At the bottom, the combustion chamber 6 is provided with a preferably circular grate bottom 12 which can be shaken or swung back and forth in a known way from the front side of the woodburning stove 2 by means of a (not shown) handle. The front side of the combustion chamber 6 is provided with a stove door 14 with heat-resistant glass pane 16. In an ash compartment 18 under the grate bottom 12, there is provided an ash pan 20. At the rear side of the stove 2, the ash compartment 18 is connected with a supply duct for primary combustion air 19 which via the ash compartment 18 is conducted up into the combustion chamber 6 through the grate bottom 12.

[0022] At the rear, the combustion chamber 6 has an inclining, upwards/forwards extending wall part 22 which consists of ceramic material, and which at the rear and at each side is supported by the ceramic walling 8. A reversing plate 24 is mounted behind the wall part 22 at an upper wall part 21 of the combustion chamber 6 such that the flue gas, cf. the arrow 23 from the combustion chamber 6, is forced downwards before it has access upwards to a flue gas exhaust 26 and chimney 28, respectively.

[0023] Between a rearmost wall part 30 and the wall part 22 is formed a horizontal, slotted feed opening 32 for secondary combustion air 33, which e.g. is supplied via a (not shown) vertical duct communicating downwards with a middle secondary regulating valve 34 in a common cabinet 36, which is located under the ash compartment 18 and which also contains a common electronic control 38.

[0024] At the back side of the woodburning stove 2, between the external convection casing 4 a rear wall 5 of the combustion chamber 6, e.g. side by side, are arranged three vertical air ducts of which one middle air duct communicates downwards with the said middle regulating valve 34 regulating the supply of secondary combustion air via the feed opening 32, while a regulating valve 40 for primary combustion air 19 communicates with a rather short air duct that opens up at the back side of the ash compartment 18, i.e. providing for regulation of the supply of primary combustion air to the combustion chamber 6 up through the grate bottom 12.

[0025] A third regulating valve 42 communicates with

a relatively long air duct running along the whole back side of the stove, and which at the top extends forward along the top side of the stove 2 to a horizontal slotted feed opening 44 along the top side of the door 14, through which tertiary combustion air 45 is supplied in such a way that the tertiary combustion air is used both as scavenging air for keeping clean the glass pane 16 and for being mixed with the flue gas at the top of the combustion air 6 with the intention of ensuring optimal combustion of all combustible gases before they reach the flue gas exhaust 26 via the reversing plate 24.

[0026] Supply of primary, secondary and tertiary combustion air 19, 33, 45 thus occurs via a common opening 46 at the back side of the woodburning stove at the bottom of the casing 4, from where all combustion air is introduced via a further common opening 48 at the bottom of the cabinet 36, after which supply of primary, secondary and tertiary combustion air 19, 33, 45 to respective air ducts takes place by means of the regulating valves 34, 40, 42 which via the electronic control 38 are controlled by each their electric motor, e.g. a step motor, 50, 52, 54.

[0027] It is to be mentioned that supply of primary, secondary and tertiary combustion air 19, 33, 45 from respective regulating valves 34, 40, 42 alternatively may occur by means of flexible hoses of non-combustible material, the hoses being run from respective regulating valves 34, 40, 42 within the external casing 4 to respective feed openings for the combustion chamber 6.

[0028] The electronic control 38 includes a thermal sensor 46 and a λ -probe 48, both disposed in the flue gas exhaust 26 and connected with the electronic control 38.

[0029] When firing a new portion of fuel, the regulating valve 40 is opened such that primary air 19 is supplied via the ash compartment 18 up through the grate bottom 16, while the secondary regulating valve 34 is closed. When reaching a temperature of the magnitude 1000° - 1200° and generation of a large amount of gas has occurred after some time, the primary regulating valve 40 is partially closed, while the secondary regulating valve 34 is partly opened and the tertiary regulating valve 42 is partly opened, controlled by the flue gas temperature (200°-350°) and the oxygen content in the flue gas which is detected by the λ -probe 48.

[0030] The woodburning stove 2 according to the invention will preferably be designed with a firing indicator, which may consist of a light diode and/or an acoustic signal emitter which by signalling will remind about the fact that wood has to be fired now in order to maintain optimal combustion.

[0031] In that connection it is to be mentioned that the λ -probe 48 continuously detects the oxygen content in the flue gas, why the automatic control can react rapidly if the oxygen content suddenly drops - e.g. in that the fuel blazes up - an optimal reaction by high temperature in the fire core (1200°) will be to open more for the regulating valve 34 secondary combustion air 33, while a corresponding reaction at lower temperature in the fire

core will be to increase the supply of primary combustion air 19 via the regulating valve 40.

[0032] Examples of connected measuring results and valve opening in %, respectively, are shown in the graphic presentations, cf. Figs. 4-8, where Fig. 4 illustrates the flue gas temperature viewed over five firings, each constituted by test firing with wood, each two kg. Fig. 5 illustrates the amount of CO (the area under the curve) as CO also includes non-detectable particles. The area under the curve in Fig. 5 represents, as mentioned, the actual amount of CO during the combusting; if the oxygen content detected by the λ -probe 48 is incorporated in the curve, cf. Fig. 5, the area under the curve will be reduced in general, i.e. the curve will approximately be displaced "in parallel" downwards. Figs. 6-8 illustrate the valve opening in % for primary, secondary and tertiary combustion air, respectively.

[0033] Figs. 9-12 show a preferred embodiment of a valve cabinet 36 which is located under the ash compartment 18 (Fig. 1), and which includes three regulating valves 34, 40, 42, where the regulating valve 40 regulates supply of primary combustion air 19, the regulating valve 34 regulates supply of secondary combustion air 33 and the regulating valve 42 regulates supply of tertiary combustion air 45 to respective feed openings 12, 32, 44 for the combustion chamber 6.

[0034] A front side 56 of the valve cabinet 36 is designed with a large number of supply openings 58 through which combustion air is generally introduced in the valve cabinet 36 which is usually provided with a not shown lower bottom plate. The cavity 60 immediately within the supply openings 58 represents a relatively cold spot in the woodburning stove 2, why the electronic control 38 is located here, possibly fastened to the not shown bottom plate.

[0035] In Fig. 9, all three regulating valves 34, 40, 42 are completely shut, while the regulating valve 40 for primary combustion air 19 in Figs. 10-12 is relatively much open, and the regulating valve 34 for secondary combustion air 33 is slightly open, while the regulating valve 42 for tertiary combustion air 45 is completely closed.

[0036] Fig. 13 shows a laboratory version of the regulating valves 34, 40, 42 with associated step motors 50, 52, 54 for primary, secondary and tertiary combustion air 19, 33, 45, respectively, which is supplied to the stove via flex hoses 62, 64, 66 with metal jacket.

[0037] It will be appreciated that the electronic control 38 enables achieving a rapid reaction by controlling the regulating valves 34, 40, 42 and good efficiency of the woodburning stove 2. With the object of the visualising the effect of the electronic control, the woodburning stove 2 may include a number of signal diodes and/or a display showing the status of the most important control parameters, and which may be wall-mounted and interact wirelessly with the electronic control 38.

[0038] Furthermore, it will be advantageous that the electronic control 38 is battery-powered such that operation of the stove 2 is independent of the public network.

The battery may possibly be adapted to be recharged via a thermocouple connected to the stove.

5 Claims

1. A method for controlling a woodburning stove of the type having a combustion chamber with a glass door, the combustion chamber having a walling at the rear and at both side and downwards being separated from an ash chamber by means of a grate bottom, and connected with a chimney via a flue gas exhaust in which the flue gas temperature is detected by means of a thermal sensor, by which method primary combustion air is supplied to the combustion chamber via the ash chamber up through the grate bottom, and secondary combustion air is supplied directly to the combustion chamber, by which method is applied an electronic control which is connected with the thermal sensor and with a λ -probe provided in the flue gas exhaust, **characterised in that** tertiary combustion air is supplied directly to the combustion chamber via a feed opening along a top side of the door, and that supply of primary, secondary and tertiary combustion air to the combustion chamber is controlled by the electronic control by means of separate control valves.

2. An electronic control for a woodburning stove of the type including a combustion chamber with a glass door, the combustion chamber being downwards separated from an ash chamber by means of a grate bottom and having a walling at the rear and at both sides which upwards has an inclining forwards/upwards extending wall part, the combustion chamber upwards being connected via a reversing plate to a chimney via a flue gas exhaust, the control including a thermal sensor and a λ -probe provided in the flue gas exhaust, **characterised in that** the control is incorporated in a cabinet which is adapted to be disposed below the ash chamber and which includes a common air intake and one or more regulating valves with a damper plate, each drivingly connected with an electric motor arranged in the cabinet, the motor being control connected with the electronic control, the regulating valve or valves interacting with air ducts for supplying primary and secondary combustion air, the air ducts being disposed side by side at a rear side of the woodburning stove.

3. Electronic control according to claim 2, **characterised in that** the cabinet includes three regulating valves, namely a first regulating valve interacting with a first air duct for supplying primary combustion air, a second regulating valve interacting with a second air duct for supplying secondary combustion air, and a third regulating valve interacting with a third air duct for supplying tertiary combustion air.

4. Electronic control according to claim 2, **characterised in that** the first air duct opens into the ash chamber above a possible ash pan, as primary combustion air is supplied to the combustion chamber through the grate bottom, and that the second air duct opens in the rear side of the combustion chamber spaced apart from the grate bottom, as secondary combustion air is supplied through a horizontal slotted opening at the transition to the inclining wall part of the combustion chamber. 5 10

5. Electronic control according to claim 2 and 3, **characterised in that** the third air duct opens into a horizontal slotted opening along the top side of a glass door at the front side of the combustion chamber, as tertiary combustion air, besides being mixed with rising gasses, is also used as scavenging air for keeping clean the inner side of the glass door. 15

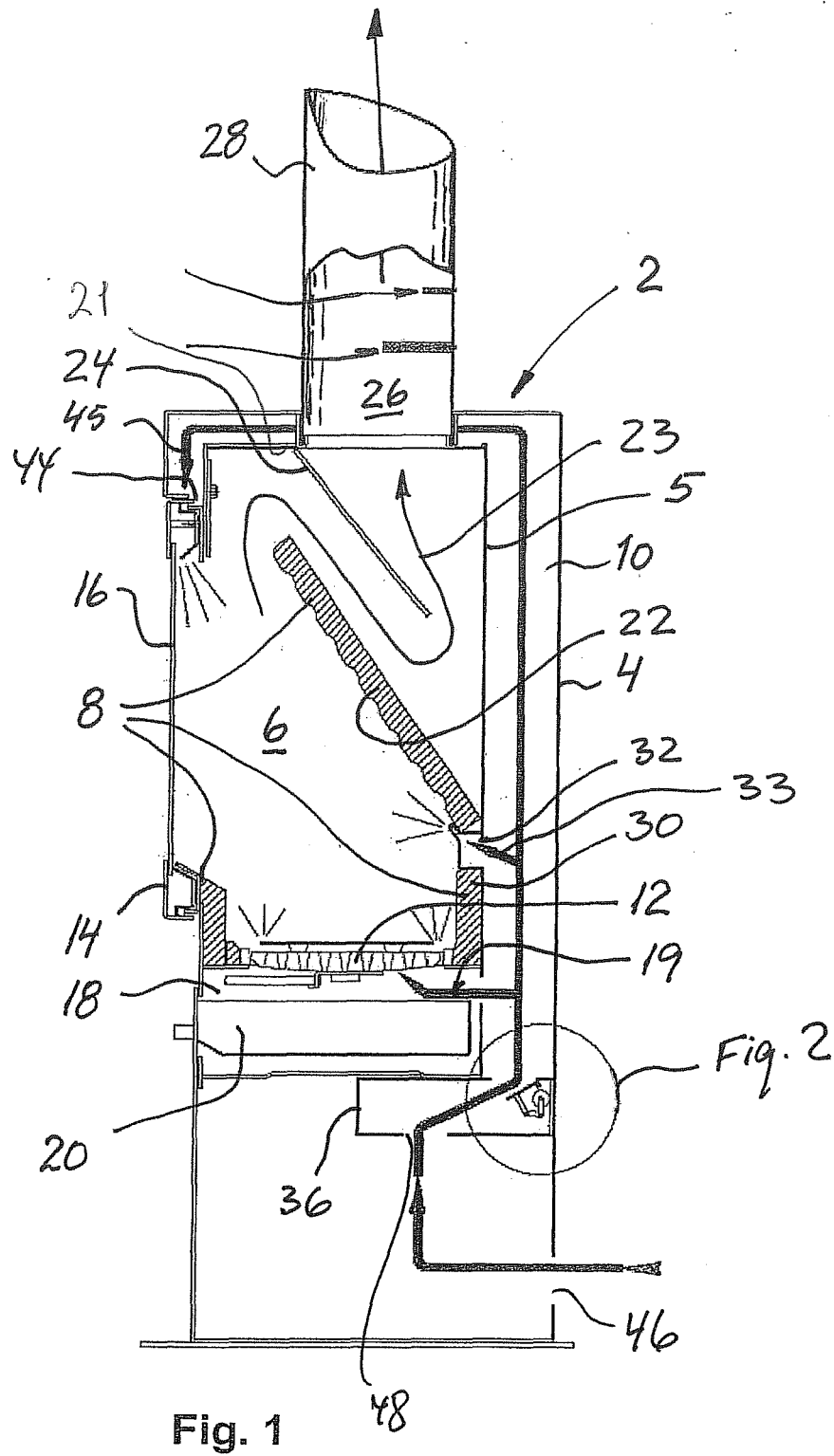
6. A woodburning stove including a combustion chamber which is downwards separated from an ash chamber by means of a grate bottom and having a walling at the rear and at both sides which upwards has an inclining forwards/upwards extending wall part, the combustion chamber upwards preferably via a reversing plate being connected with a chimney via a flue gas exhaust, the woodburning stove including an electronic control which includes a thermal sensor and a λ -probe provided in the flue gas exhaust, **characterised in that** the control is incorporated in a cabinet which is adapted to be disposed below the ash chamber and which includes a common air intake and one or more regulating valves with a damper plate, each drivingly connected with an electric motor arranged in the cabinet, the motor being control connected with the electronic control, the air valves interacting with air ducts for supplying primary and secondary combustion air, the air ducts being disposed side by side at a rear side of the woodburning stove. 20 25 30 35 40

7. Woodburning stove according to claim 6, **characterised in that** the cabinet includes three air valves, namely a first air valve interacting with a first air duct for supplying primary combustion air, a second air valve interacting with a second air duct for supplying secondary combustion air, and a third air valve interacting with a third air duct for supplying tertiary combustion air. 45 50

8. Woodburning stove according to claim 6 and 7, **characterised in that** the first air duct opens into the ash chamber above a possible ash pan, as primary combustion air is supplied to the combustion chamber through the grate bottom, and that the second air duct opens in the rear side of the combustion chamber spaced apart from the grate bottom, as secondary combustion air is supplied through a horizontal 55

slotted opening at the transition to the inclining wall part of the combustion chamber.

9. Woodburning stove according to claim 6 and 7, **characterised in that** the third air duct opens into a horizontal slotted opening along the top side of a glass door at the front side of the combustion chamber, as tertiary combustion air, besides being mixed with rising gasses, is also used as scavenging air for keeping clean the inner side of the glass door.



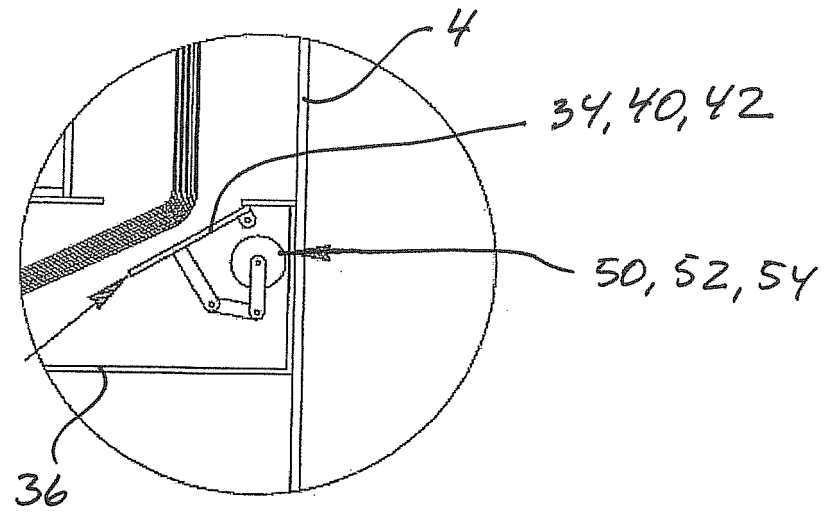


Fig. 2

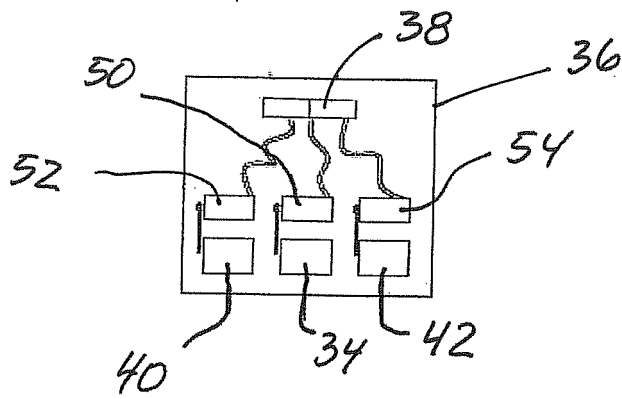


Fig. 3

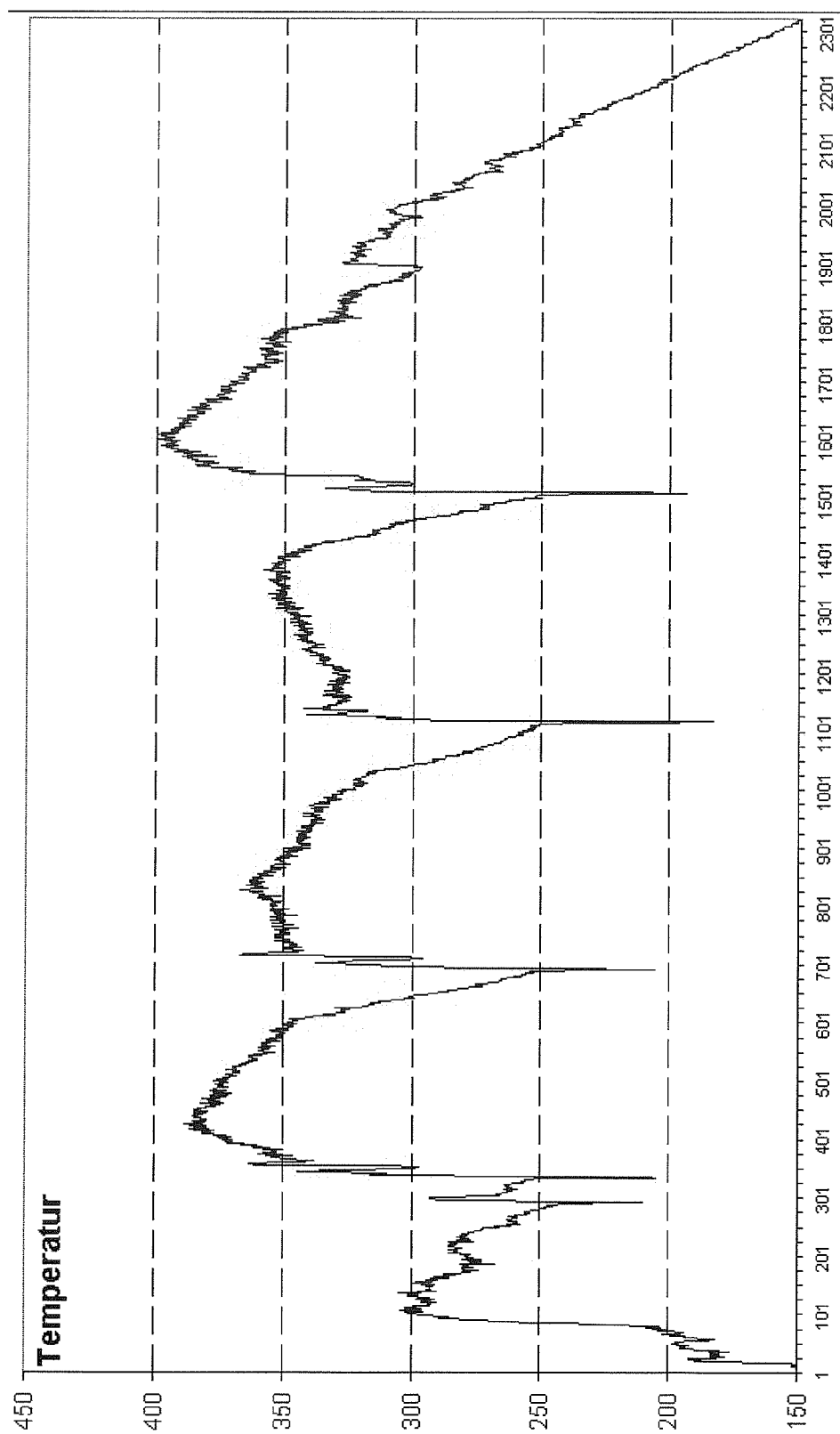


Fig. 4

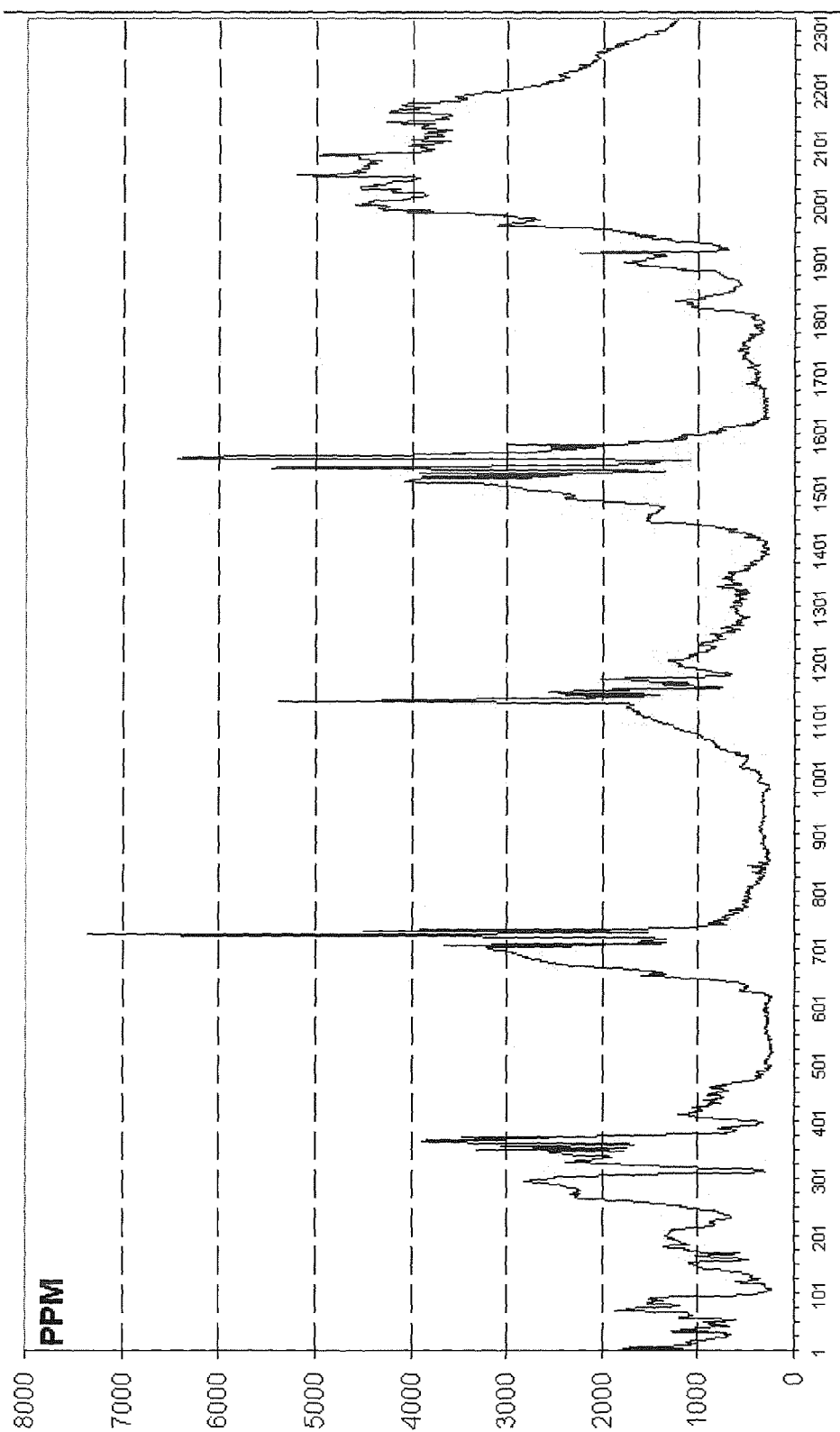


Fig. 5

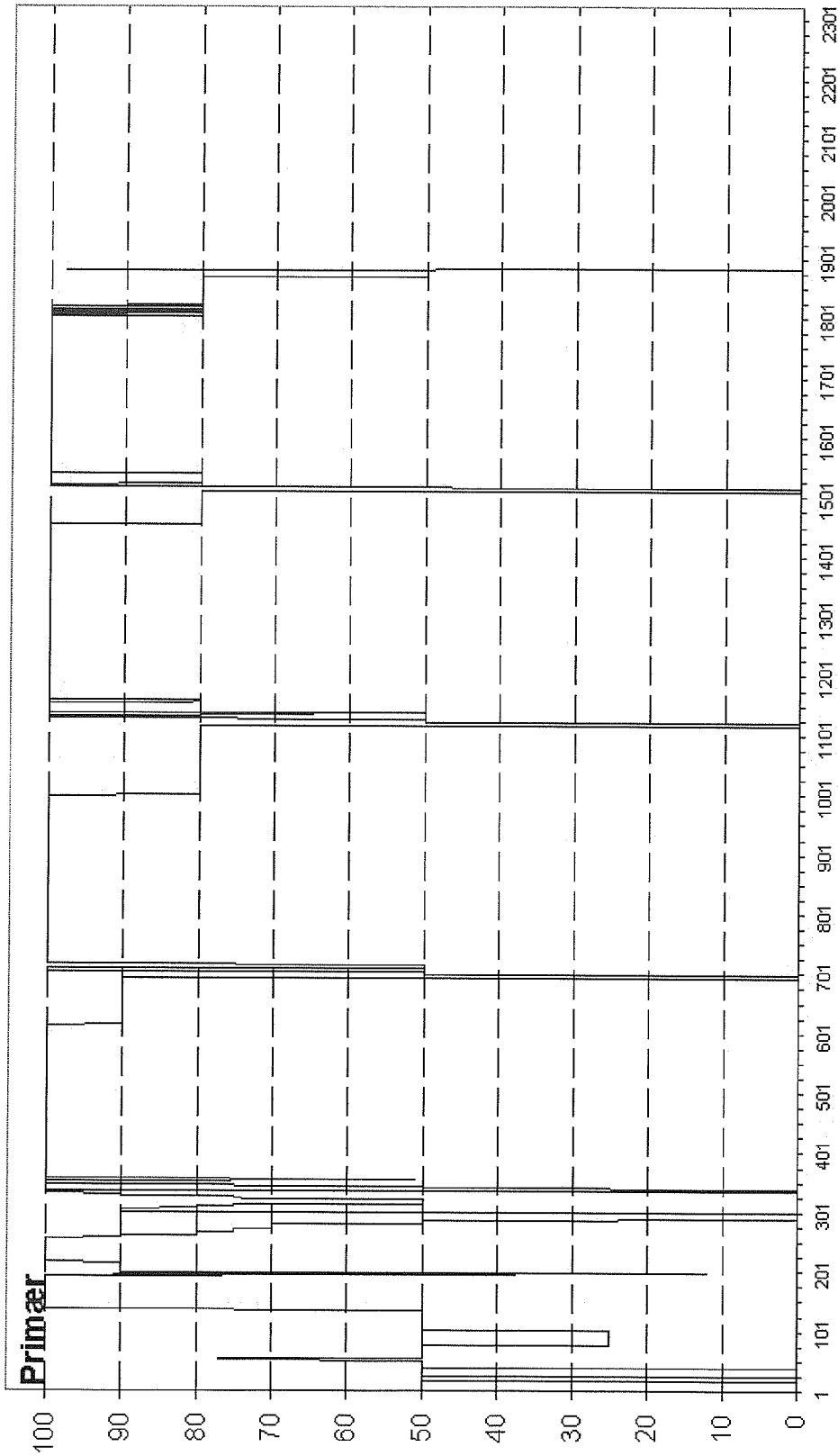


Fig. 6

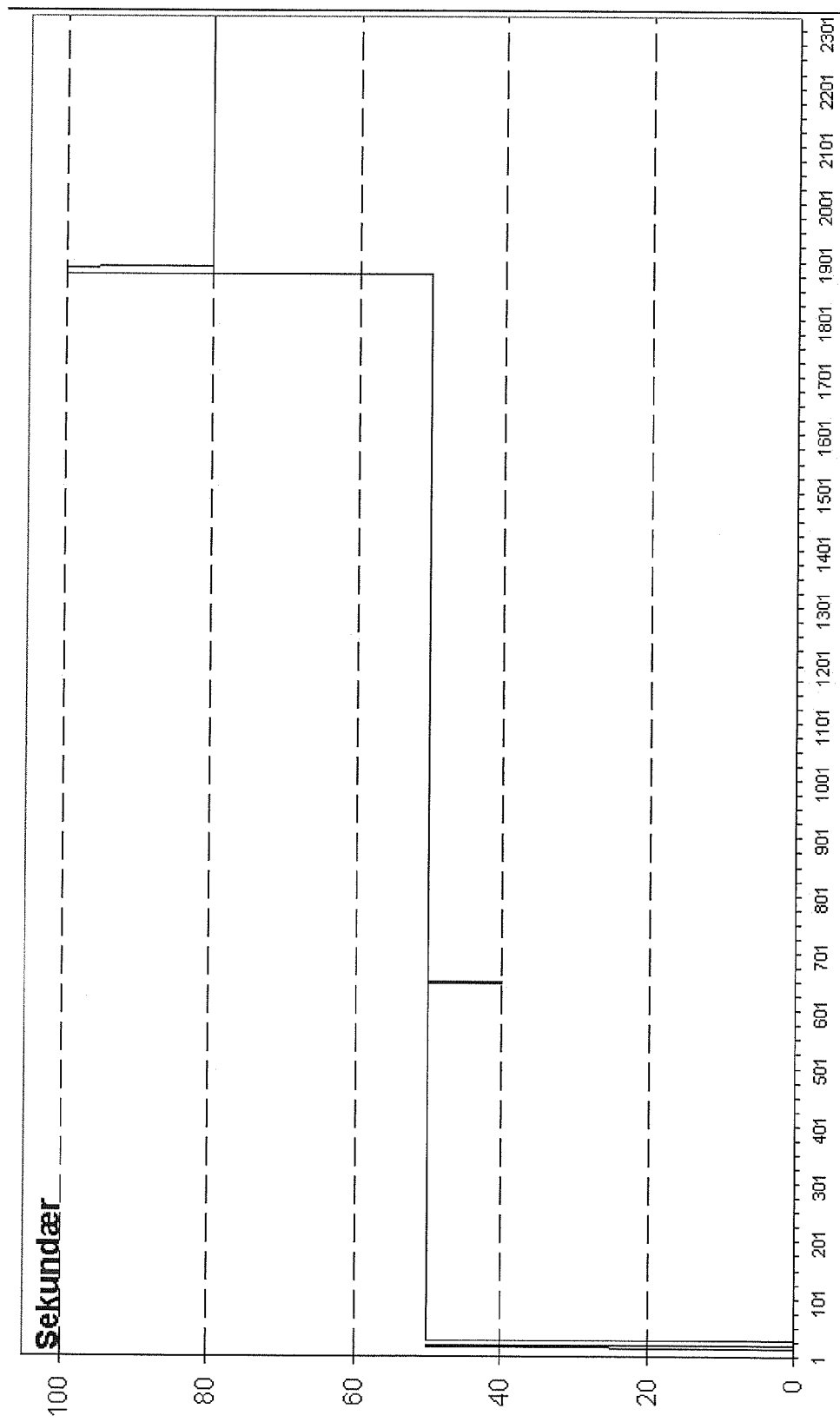


Fig. 7

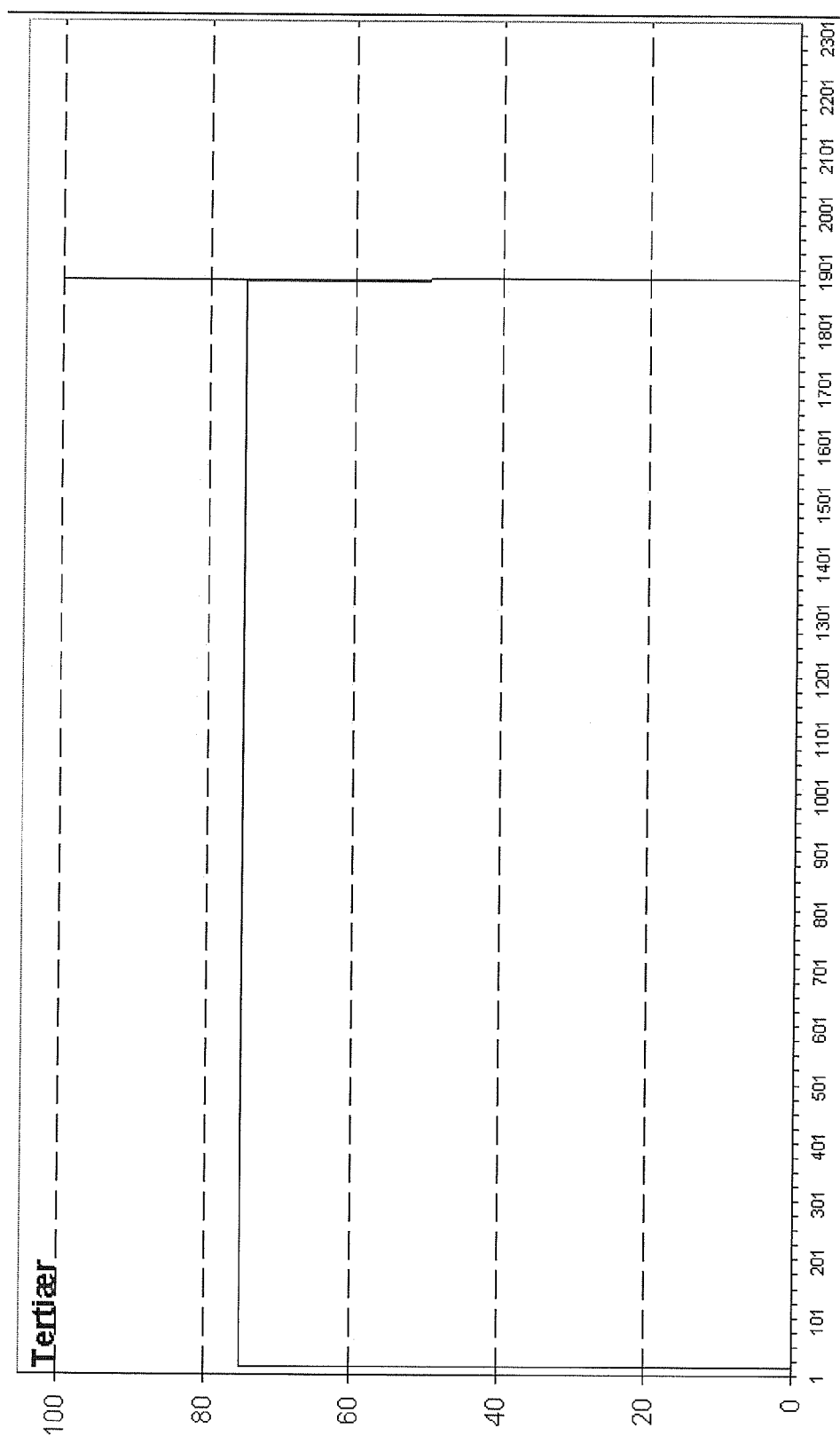


Fig. 8

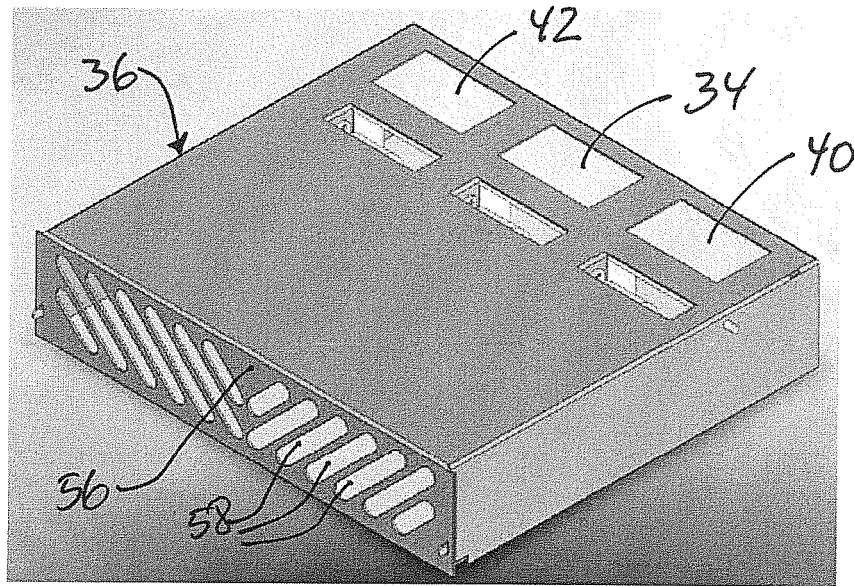


Fig. 9

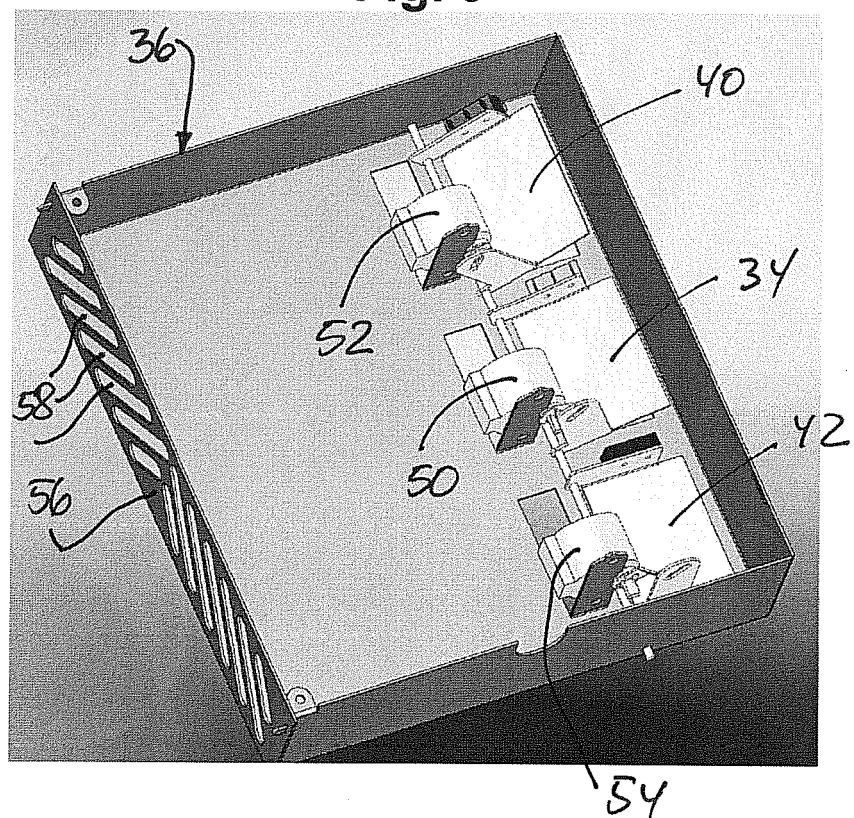


Fig. 10

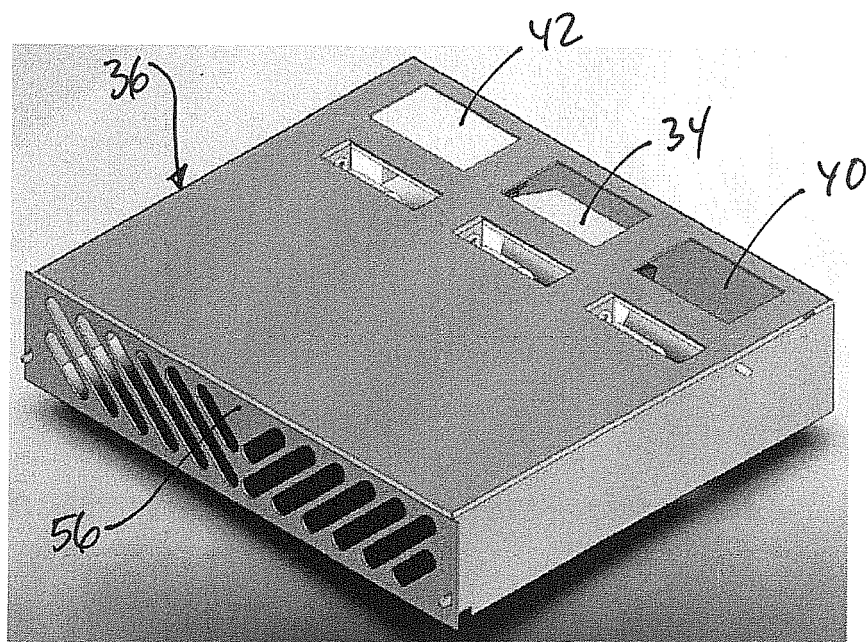


Fig. 11

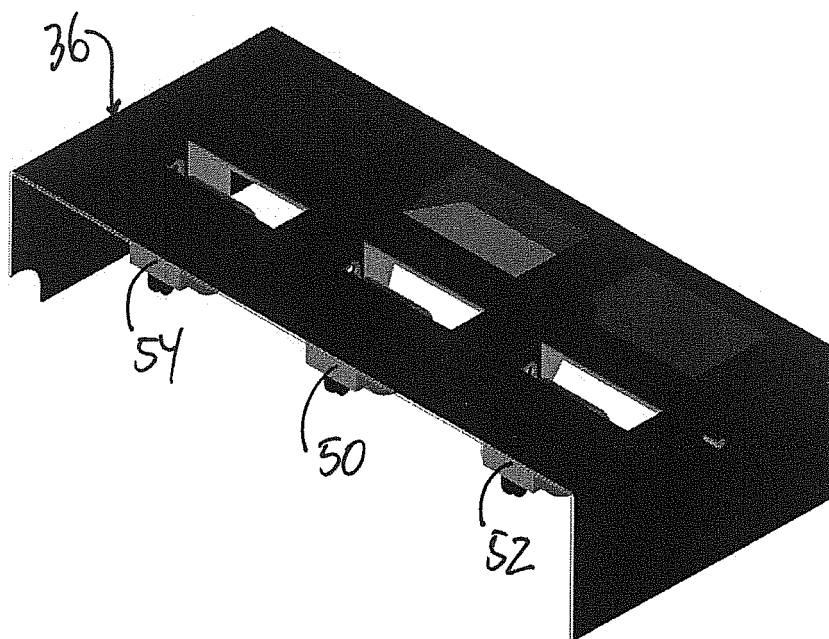
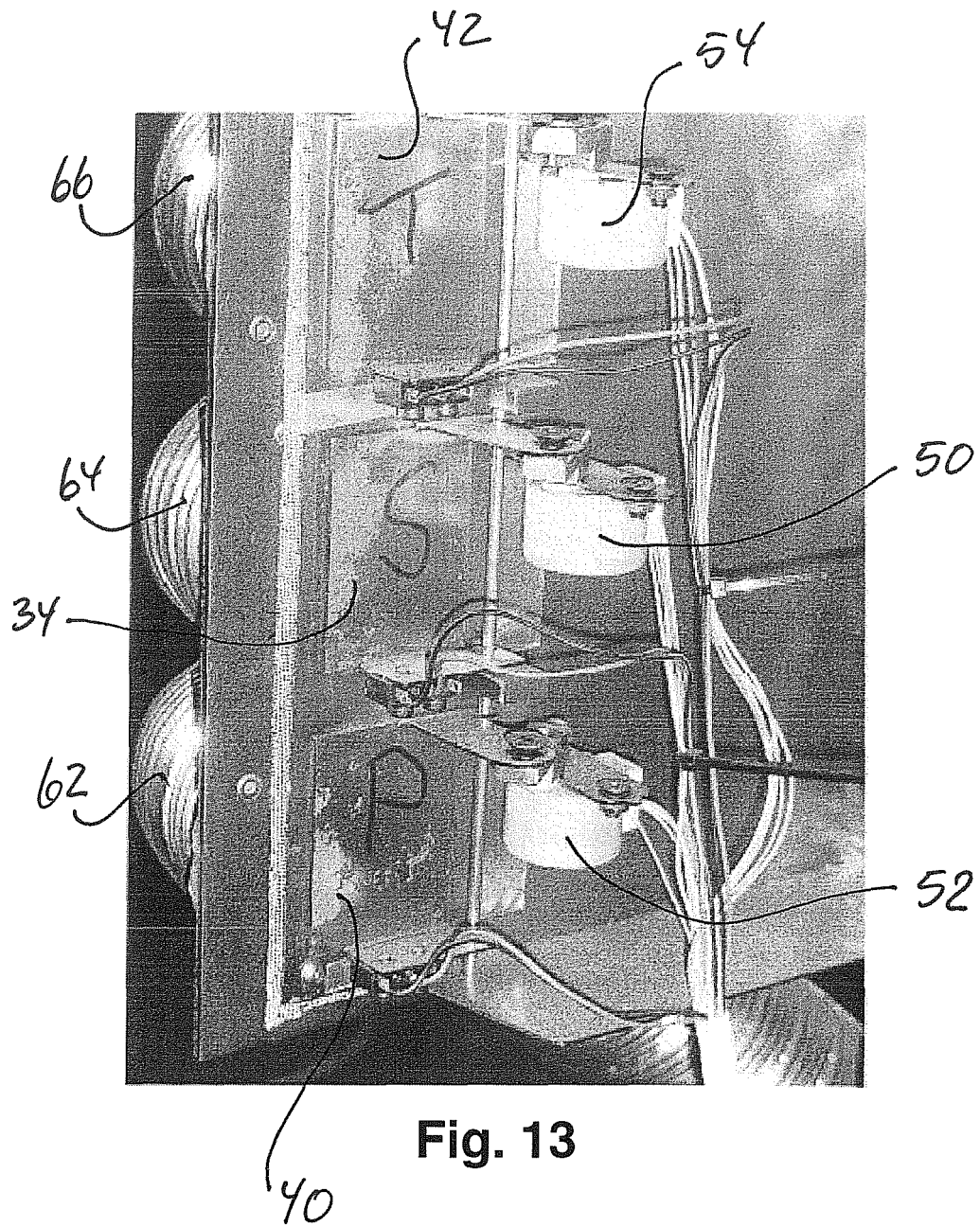


Fig. 12



REFERENCES CITED IN THE DESCRIPTION

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