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(54) **POST-COMBUSTION DEVICE, FOR FILTERING AND REDUCING EMISSION OF PARTICULATE AS WELL AS OPTIMIZING THERMAL PERFORMANCE AND METHOD OF OPERATING SUCH A DEVICE**

NACHVERBRENNUNGSVORRICHTUNG ZUM FILTERN UND VERRINGERN VON TEILCHENEMISSIONEN SOWIE OPTIMIEREN DER WÄRMELEISTUNG UND VERFAHREN ZUM BETRIEB EINER SOLCHEN VORRICHTUNG

DISPOSITIF DE POSTCOMBUSTION, POUR FILTRER ET RÉDUIRE L'ÉMISSION DE PARTICULES ET POUR OPTIMISER LA PERFORMANCE THERMIQUE ET MÉTHODE DE FONCTIONNEMENT D'UN TEL DISPOSITIF

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(74) Representative: **Bettello, Pietro**
Studio Tecnico
Ingg. Luigi e Pietro Bettello
Via Col d'Echele, 25
36100 Vicenza (IT)

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(73) Proprietor: **Dal Pra', Robert**
36010 Cogollo Del Cengio (VI) (IT)

(72) Inventor: **Dal Pra', Robert**
36010 Cogollo Del Cengio (VI) (IT)

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Description

[0001] The present finding concerns a post-combustion device, for filtering and reducing emission of particulate as well as optimizing thermal performance, to be used on biomass fuelled burners.

[0002] As it is well known, the main problem regarding the use of combustion heating appliances based on boilers equipped with biomass fuelled burners (wood, pellets, wood chips, oil seeds and other similar material), especially when used for domestic purposes - stoves, boilers and fireplaces - concerns optimising thermal performance (recovery of combustion heat) alongside ensuring least pollution possible (lowest emission of combustion products into the atmosphere).

[0003] According to the current state of the art, there are several stove and fireplace performance enhancement methods. Some of these methods include creating airflows in the fire chamber thus enhancing combustion and consequently reducing emissions (for example as described in the V193A000161 Italian patent). Alternatively, the heating appliance can be equipped with a chamber with a secondary airflow or a water coil which, upon contact with the combustion exhaust gases, transfers some of the heat from the gases mentioned beforehand to the transfer fluid, thus increasing the appliance's thermal performance (for example as described respectively in the 253.010 and VI2004A000049 Italian patents).

[0004] In the document D1 WO2007/036974 A, which is considered to represent the most relevant State of the Art, is disclosed an economizer/environmentally-friendly device; another similar device is described in DE3331545: it describes a similar device in which the exhausted gases are treated using only an electrostatic filter.

[0005] This patent aims at manufacturing a combustion heating appliance capable of guaranteeing both enhanced thermal performance and low pollution compared to corresponding parameters of similar products already known.

[0006] This can be achieved by means of a device to be applied downstream a burner - to be found in wood, pellet, wood chips, oil seeds and generally biomass fuelled stoves/boilers - comprising at least one mechanical pre-filter (a cyclone filter), at least one smoke ionization chamber, at least one electrostatic collection filter (made of a cellular monolithic catalyst with an impregnated metal substrate), at least one oxygen addition intake to control post-combustion, at least one post-filtration electrostatic chamber, at least one heat exchanger, at least one suction device used to create depression along the entire gases route (burner - cyclone pre-filter - ioniser - collector/catalyst - electrostatic post-filter - heat exchanger).

[0007] Constructively, a cyclone separator may be used for mechanical pre-filtration operations. Such cyclone separator is used to remove heavy visible particles (ash for instance which could end up settling on the cat-

alyst substrate and thus clogging it) from the smoke generated following normal combustion. Such particles end up in a removable collection tray under the appliance.

[0008] Then, once the coarse particles are removed through the cyclone separator, smoke is channelled into the primary ionizing section, where there is an exhaust gases ionization chamber, made of a metal sheet mesh with a 10 kV electrostatically charged catalyzing substrate, to cause particulate polarisation. Next, the electrically charged gases are channelled into an electrostatic filtering collector, made of a catalyst with a previously treated and earthed metal substrate, operating as a post-burner through combustion of the CO (carbon monoxide) previously mixed with oxygen and of the particulate electrostatically collected and applied on the surface of the abovementioned substrate.

[0009] More precisely, the catalyst serves as a collector in the electrostatic scrubbing process, collecting fine dusts while converting harmful substances - both to health and environment - usually produced by biomass combustion into harmless substances. This occurs through surface chemical reactions taking place onto the heated metal substrate previously coated with noble metals (such as platinum, palladium and rhodium) which cause oxidation of carbon monoxide and other unburned hydrocarbons, converting them into carbon dioxide and water alongside the reduction of nitrogen oxides and fine dusts, commonly referred to as PM₁₀, (environmentally friendly outcome).

[0010] In addition, when the gases generated by combustion pass through the catalyst mentioned beforehand, not only do they undergo a chemical conversion, but they also trigger a post-combustion process of the of the gases still unburned after the first stage, thus increasing the temperature of the gases (reaching 800°C) exiting from the catalyst mentioned beforehand considerably (heat recovery).

[0011] Advantageously, according to the finding, a secondary electrostatic filter, comprising a two-stage electrostatic chamber made of metal sheet with a treated substrate, made up of an ionising section and a collection section, can be arranged downstream the catalyst.

[0012] The electrostatic two-stage chamber mentioned beforehand collects the fine dusts (diameter below 1 µm) produced during the initial igniting stage of the burner. These fine dusts remain unburned after going through the previous post-combustion group, as this is still inefficient within that ignition period of time due to low temperatures at that stage. Once the post-burner reaches the temperature required for regular operation, the secondary electrostatic filter is disabled and its collection surface is cleaned up under the effect of the high temperature of the gases exiting from the post-burner.

[0013] Then, the gases mentioned beforehand, purified and considerably hot exiting from the catalyst, pass through a heat exchanger thus recovering the greater part of the heat held in the post-burner gases. This heat exchanger is used to produce hot water or heated air for

the environment.

[0014] Exploiting the maximum thermally conductive surface, the ideal performance of a bundle heat exchanger can be obtained only by positioning said exchanger after the particulate filtration system, thus allowing the scrubbing of fine dusts. Indeed, were said dusts still present during the thermal exchange stage, they disadvantageously would settle onto the internal walls of the exchanger, thus reducing its performance i.e. external thermal conduction.

[0015] Lastly, a suction device is fixed at the end of the exhaust gas pipe where gases have already considerably cooled down. Such suction device is used to create depression along the canal outlining the entire exhaust gas route, thus starting the suction operation directly from the combustion chamber of the heating appliance.

[0016] The entire system shall be fixed downstream the combustion chamber of the heating appliance. Basically, this is due to the fact that the system should collect burnt gases while they are still flames and at temperatures not below 300-350°C, the maximum value required to neutralise polluting gas substances through the catalyst.

[0017] Practically, laboratory tests have proved that upon final exit, not only are the exhaust gases free of polluting dusts (environmental benefit) but they also transfer most of their heat compared to the traditional systems (energy saving).

[0018] This finding shall be explained in details through a description of a possible embodiment, as illustrative but not limiting examples, with the help the annexed drawings, wherein:

- fig.1 illustrates a front elevation view of the device according to the finding;
- fig.2 illustrates a side view of the abovementioned device, partially cross-sectioned by line II-II of fig.1;
- fig.3 illustrates an overall view of the filtering group;
- fig.4 illustrates an exploded view of the group according to fig 3;
- fig.5 illustrates a cross-section, according to line V-V of fig 4, under the filtering group;
- fig. 6 illustrates a cross-section, according to line VI-VI of fig 3, under the filtering group;
- fig.7 illustrates a block diagram of how the device operates according to the finding;

[0019] From the operational point of view, the device 1 provided for by this finding operates in five stages: in the first stage, mechanical pre-filtration of coarse particulate occurs, as illustrated in the drawing at F1; (fig. 1); in the second stage, oxygen regulated ionization and mixing occurs as illustrated in the drawing at F2; in the third stage, collection of fine dusts alongside conversion and post-combustion of gases occurs with electrostatic precipitation as illustrated in the drawing at F3; in the fourth stage, electrostatic post-filtration of fine particulate occurs as illustrated in the drawing at F4 and in the fifth

stage, heat exchange with the external environment occurs as illustrated in the drawing at F5.

[0020] As illustrated by the drawings, in the first operational stage, the exhaust gases find their way from the combustion chamber "C" into the mechanical separation filter through the pipe 2. Said filter is made of a cyclone 3, which separates coarse particles, which in turn settle in a manually removable tray 4 beneath.

[0021] Subsequently, the combustion gas exits from the upper collector 5 of the cyclone 2 then it undergoes mechanical pre-filtration and addition of oxygen coming from an external source through an intake canal 6 equipped with an automatic gate valve 6.1.

[0022] Next, in the second stage, by means of a pipe 7, the gas is channelled through an ionization chamber 8 supplied with a 10 kV positive electric charge, through which it is treated, charging the fine particles still present after the first mechanical filtration stage electrostatically.

[0023] After that, particulate collection is performed in the third stage through the action of the metal substrate of a cellular catalyst 9 earthed with negative charge.

[0024] Through surface post-combustion of the substrate at high temperatures, the substrate mentioned beforehand - treated using noble metals such as platinum, palladium and rhodium - serves to eliminate the unburned substances, cause oxidation of carbon monoxide and unburned hydrocarbons converting them into carbon monoxide and water, alongside reducing nitrogen oxide and PM₁₀ (environmentally friendly purpose).

[0025] There is a two-stage electrostatic chamber 10, directly coupled with the catalyst 9. This chamber, completing the fourth stage, is used to collect fine dusts (diameter below 1 µm) produced during the initial igniting stage of the burner and not neutralised during the previous phase in that the catalyst 9 has not yet reached the required temperature.

[0026] Such two-stage electrostatic chamber 10, made of the same material as the previous cellular catalyst 9, consists of a first stage 10.1 which allows ionization of particles at 7,5 and 10 kV (positive pole) not collected by the catalyst mentioned beforehand, due to low temperature or due to temperature excursions under normal operation conditions (change of temperature/speed, on/off, lack of combustion). The two-stage electrostatic chamber 10 also consists of a second stage 10.2 used to collect previously ionised particles, settling the rejected particles of the charged substrate at a 1/3 of the ionization voltage, on the earthed surface.

[0027] In the fifth stage, through a pipe 11, the gases are channelled into a high exchange surface tube bundle heat exchanger 12, where heat exchange occurs with environment air/air or air/water and where gas intake occurs from the top towards the bottom while the tube bundle encloses the entire post-combustion group (8,9,10) thus allowing to recover even the heat produced by the previously mentioned post combustion group surface coating, through the circulation of air to perform the heat exchange.

[0028] A suction motor 13, is fixed onto the heat exchanger 12 on the "S" openings. Such suction motor sucks cooled gases keeping the depression along the entire appliance at a constant level and releases said gases.

[0029] The descriptions above show the benefits achieved through the use of the device provided for by this finding. In particular, this device performs heat exchange and combustion exhaust gas purification operations occupying little space and with maximum performance.

[0030] Obviously, the device herein described may be made according to different embodiments, depending on the dimensions and type of components used, provided that such methods comply with the following claims.

Claims

1. POST-COMBUSTION DEVICE USED FOR FILTERING AND REDUCING EMISSION OF HARMFUL PARTICULATE as well as OPTIMIZING THERMAL PERFORMANCE, to be used on biomass, wood, pellet, wood chips, oil seeds and other similar products fuelled burners, especially for domestic use appliance such as stoves and fireplaces, said device (1) being **characterised in that** it comprises at least one mechanical cyclone filter (3), at least one primary ionization chamber (8), at least one catalytic post-combustion precipitator or a grounded catalyst (9), at least one two-stage electrostatic filter (10), at least one heat exchanger (12) and at least one suction device (13) aimed at creating a depression along the gases route and at releasing said gases.
2. DEVICE, according to claim 1 **characterised in that** it serves as a post-burner and **in that** it is positionable downstream the combustion chamber "C" of a biomass fuelled heating appliance.
3. DEVICE, according to claim 2 **characterised in that** it serves as a filtration system for particulate generated by the combustion of biomass.
4. DEVICE, in according to claim 2 **characterised in that** the catalyst (9) is of the metal monolithic kind, with a cellular substrate impregnated with noble metals such as platinum, palladium or rhodium, which cause oxidation of carbon monoxide and unburned hydrocarbons converting them into carbon dioxide and water.
5. DEVICE, according to claim 3, **characterised in that** the ionization chamber (8) has a 10 kV electric charge and it is positioned before the catalyst (9).
6. DEVICE, according to claim 3 **characterised in that** the post-combustion inside the catalyst is optimised through addition of oxygen directly from an external source through a pipe (6) equipped with a self-regulated valve (6.1).
7. DEVICE, according to claim 1, **characterised in that** the catalyst (1), being earthed, serves as an element collector for fine dusts.
8. DEVICE, according to claim 4 **characterised in that** the primary ionization causes settling of particulate in the catalyst substrate, even when the latter has not reached required post-combustion operation temperatures.
9. DEVICE, one or more of the previous claims **characterised in that** the two-stage electrostatic filter (10), positioned after the catalytic post-burner (9) is of the two-stage type with double voltage (10 kV - 7.5 kV) and it consists of an ionising section (10.1) and a collection section (10.2), which prevents leakage of particles from the catalyst (9).
10. DEVICE, according to claim 8 **characterised in that** the two-stage electrostatic filter (10) is positioned after the catalyst (9), and is made of the same material as the abovementioned catalyst, thus avoiding ongoing manual cleaning of the precipitator positioned after the ionising section (10.1) through surface combustion of the particulate deposited on the substrate, triggered by the high temperature of the gas produced by the previous post-combustion.
11. DEVICE, according to one or more of the previous claims **characterised in that** the electrostatic filter (10) performs filtration operations withholding any dusts and gases produced due to poor post-combustion, irregular operation of the heating appliance or malfunctions during burner on/off operations.
12. DEVICE, according to one or more of the previous claims **characterised in that** the heat exchanger (12) is a tube bundle exchanger with gas intake from the top towards the bottom thus allowing heat to spread over the entire surface of the same exchanger.
13. DEVICE, according to one or more of the previous claims **characterised in that** the heat exchanger (12) encloses the post-burner group (8,9,10) thus allowing to recover even the heat produced by the surface coating of the same post-burner through air circulation within the same post-burner.
14. METHOD OF operating a DEVICE according to one of more of the previous claims, **characterised in that** the device (1) provided for by this finding operates in five stages: a first stage (F1), where mechan-

ical pre-filtration of coarse particles occurs; a second stage (F2) where oxygen regulated ionization and mixing occurs; a third stage (F3), where collection of fine dusts occurs alongside conversion and post-combustion of gases with electrostatic precipitation; a fourth stage (F4), where electrostatic post-filtration of fine particulate occurs; a fifth stage (F5) where heat exchange with the external environment occurs.

15. HEATING APPLIANCE, such as a wood, pellet, wood chip, oil seeds and generally biomass fuelled stove/burner **characterised in that** it is equipped with the energy saving/environmentally friendly device (1) made according to one or more of claims 1 to 13.

Patentansprüche

1. NACHVERBRENNUNGSVORRICHTUNG ZUM FILTERN UND VERRINGERN DER REMISSION VON SCHÄDLICHEN PARTIKELN SOWIE ZUM OPTIMIEREN DER WÄRMELEISTUNG, zur Verwendung in mit Biomasse, Holz, Pellets, Holzhack-schnitzeln, Ölsamen und anderen ähnlichen Erzeugnissen befeuerten Brennern insbesondere für Geräte für den Hausgebrauch wie öfen und Kamine, wobei diese Zurrichtung (1) **dadurch gekennzeichnet** ist, das sie mindestens ein mechanisches Zyklonfilter (3), mindestens eine Primörionisierungskammer (8), mindestens einen katalytischen Nachverbrennungsabscheider oder einen geerdeten Katalysator (9), mindestens ein zweistufiges elektrostatisches Filter (10), mindestens einen Wärmetauscher (12) und mindestens eine Saugvorrichtung (13) umfasst, die dazu dient, einen Unterdruck längs des Weges der Gase zu erzeugen und diese Gase freizusetzen.
2. VORRICHTUNG nach Anspruch 1 **dadurch gekennzeichnet, dass** sie als Nachbrenner dient, und dadurch, dass sie stromabwärts der Brennkammer "C" eines mit Biomasse befeuerten Heizgeräts angeordnet werden kann.
3. VORRICHTUNG nach Anspruch 2, **dadurch gekennzeichnet, dass** sie als Filtrationssystem für Artikel dient, die beim Verbrennen von Biomasse erzeugt werden.
4. VORRICHTUNG nach Anspruch 2, **dadurch gekennzeichnet, dass** der Katalysator (9) von der Art eines Metallmonolithen mit einem mit Edelmetallen wie Platin, Palladium oder Rhodium imprägnierten zellulären Träger ist, der die Oxydation von Kohlenmonoxid und unverbrannten Kohlenwasserstoffen bewirkt und sie in Kohlenstoffdioxid und Wasser um-

wandeln

5. VORRICHTUNG nach Anspruch 3, **dadurch gekennzeichnet, dass** die Ionisierungskammer (8) eine elektrische Ladung von 10 kV hat und vor dem Katalysator (9) angeordnet ist.
6. VORRICHTUNG nach Anspruch 3, **dadurch gekennzeichnet, dass** die Nachverbrennung im Katalysator durch Zugabe von Sauerstoff direkt von einer externen Quelle durch ein Rohr (6) optimiert wird, das mit einem selbstregelnden Ventil (6.1) ausgestattet ist.
7. VORRICHTUNG nach Anspruch 1, **dadurch gekennzeichnet, dass** der geerdete Katalysator (1) als ein Kollektorelement für Feinstäube dient.
8. VORRICHTUNG nach Anspruch 4, **dadurch gekennzeichnet, dass** die Primärionisierung das Ablagern der Partikel im Katalysatorträger auch dann bewirkt, wenn letzterer nicht die erforderlichen Betriebstemperaturen für die Nachverbrennung erreicht hat.
9. VORRICHTUNG nach einem oder mehrere der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das nach dem katalytischen Nachbrenner (9) ungeordnete zweistufige elektrostatische Filter (10) des zweistufigen Typs mit zwei Spannungen (10 kV) - 7,5 kV) ist und aus einer Ionisierungszone (10.1) und einer Kollektorzone (10.2) besteht, was das Austreten von Partikeln aus dem Katalysator (9) verhindert,
10. VORRICHTUNG nach Anspruch 8, **dadurch gekennzeichnet, dass** das zweistufige elektrostatische Filter (10) nach dem Katalysator (9) angeordnet ist und aus dem gleichen Material wie der vorgenannte Katalysator besteht und somit durch die Oberflächenverbrennung der auf dem Träger abgelagerten Partikel, die durch die hohe Temperatur des durch die vorhergehende Nachverbrennung erzeugten Gases ausgetöst wird, die ständige manuelle Reinigung des nach der Ionisierungszone (10.1) angeordneten Abscheiders vermieden wird.
11. VORRICHTUNG nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das elektrostatische Filter (10) Filtrationsvoigänge ausführt und alle Staube und Gase zurückhält, die aufgrund einer mangelhaften Nachverbrennung, eines unregelmäßigen Betriebes des Heizgeräts oder von Fehlfunktionen während der Vorgänge zum Ein- und Ausschalten des Brenners erzeugt werden,
12. VORRICHTUNG nach einem oder mehreren der

vorhergehenden Anspruch, **dadurch gekennzeichnet, dass** der Wärmetauscher (12) ein Rohr-bündelwärmetauscher mit Gaseintritt von der Oberseite zum Boden hin ist und somit ermöglicht, dass sich die Hitze über die gesamte Oberfläche dieses Wärmetauschers verteilt.

13. VORRICHTUNG nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Wärmetauscher (12) die Nachbrennerbaugruppe (8, 9, 10) einschließt und es somit ermöglicht, auch die von der Oberflächenbeschichtung des Nachbrenner erzeugte Hitze durch die Luftzirkulation innerhalb dieses Nachbrenners zurückzugewinnen.

14. VERFAHREN ZUM BETREIBEN EINER VORRICHTUNG nach einem oder mehreren der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die erfindungsgemäße Vorrichtung (1) mit fünf Stufen arbeitet: einer ersten Stufe (F1), wo die mechanische Vorfiltration von Grobpartikel erfolgt; einer zweiten Stufe (F2), wo die sauerstoffregulierte Ionisierung und das Mischen erfolgen, einer dritten Stufe (F3), wo das Auffangen der Feinstäube zusammen mit der Umwandlung und Nachverbrennung von Gasen mit elektrostatischer Abscheidung erfolgt; einer vierten Stufe (F4), wo die elektrostatische Nachfiltration der Feinpartikel erfolgt; einer fünften Stufe (F5), wo der Wärmeaustausch mit der äußeren Umgehung erfolgt.

15. HEIZGERÄT wie ein mit Holz, Pellets, Holzhock-schnitzeln, Ölsamen und allgemein Biomasse befeuerter Ofen/Brenner, **dadurch gekennzeichnet, dass** es mit einer energiesparenden/umweltfreundlichen Vorrichtung (1) ausgestattet ist, die nach einem oder mehreren der Ansprüche 1 bis 13 ausgeführt ist.

Revendications

1. Dispositif de post-combustion utilisé aussi bien pour filtrer et réduire l'émission de particules nuisibles que pour optimiser la performance thermique, à utiliser sur des brûleurs alimentés en biomasse, bois, granules, copeaux de bois, graines oléagineuses et d'autres produits similaires, notamment pour des équipement à usage domestique tels que des poêles et des cheminées, ledit dispositif (1) étant **caractérisé en ce que** il comprend au moins un filtre à cyclone mécanique (3), au moins une chambre de ionisation primaire (8), au moins un précipitateur de post-combustion catalytique ou un catalyseur broyé (9), au moins un filtre électrostatique deux étages (10), au moins un échangeur de chaleur (12) et au moins un dispositif d'aspiration (13) visé à créer une

dépression le long du trajet des gaz et à libérer lesdits gaz.

2. Dispositif selon la revendication 1 **caractérisé en ce que** il sert de post-brûleur et il peut être positionné aval de la chambre de combustion « C » d'un équipement de réchauffage alimenté en biomasse.

3. Dispositif selon la revendication 2 **caractérisé en ce que** il sert de système de filtration pour les particules générées par la combustion de biomasse.

4. Dispositif selon la revendication 2, **caractérisé en ce que** le catalyseur (9) est du type monolithique métallique, avec un substrat cellulaire imprégné de métaux nobles tels que platine, palladium ou rhodium, qui entraînent l'oxydation du monoxyde de carbone et des hydrocarbures non-brûlés en les transformant en dioxyde de carbone et eau.

5. Dispositif selon la revendication 3, **caractérisé en ce que** la chambre de ionisation (8) a une charge électrique de 10 kV et elle est positionnée avant le catalyseur (9).

6. Dispositif selon la revendication 3, **caractérisé en ce que** la post-combustion à l'intérieur du catalyseur est optimisée par l'addition d'oxygène directement d'une source externe par le moyen d'un tuyau (6) muni d'une soupape autorégulatrice (6.1).

7. Dispositif selon la revendication 1, **caractérisé en ce que** le catalyseur (1), puisque il est mis à la terre, sert d'élément collecteur de poussières fines.

8. Dispositif selon la revendication 4, **caractérisé en ce que** la ionisation primaire entraîne la déposition des particules sur le substrat du catalyseur, même au cas où celui-ci n'ait pas rejoint les températures opérationnelles de post-combustion demandées.

9. Dispositif selon l'une ou plusieurs des revendications précédentes **caractérisé en ce que** le filtre électrostatique à deux étages (10), positionné après le post-brûleur catalytique (9) est du type à deux étages à double tension (10 kV- 75 kV) et il est constitué par une section de ionisation (10.1) et une section de collecte (10.2), ce qui prévient la fuite des particules du catalyseur (9).

10. Dispositif selon la revendication 8 **caractérisé en ce que** le filtre électrostatique à deux étages (10) est positionné après le catalyseur (9) et il est réalisé dans le même matériel que le catalyseur mentionné ci-dessus, ce qui permet d'éviter le nettoyage manuel régulier du précipitateur positionné après la section de ionisation (10.1) par l'intermédiaire de la combustion superficielle des particules déposées sur le

substrat, amorcée par la température élevée du gaz produit par la post-combustion précédente.

11. Dispositif selon l'une ou plusieurs des revendications précédentes caractérisé en ce que le filtre électrostatique (10) exécute des opérations de filtration en retenant toute poussière et gaz produits à cause d'une post-combustion insatisfaisante, d'un fonctionnement irrégulier de l'appareil de réchauffage ou des défauts pendant les opérations d'allumage/éteignement du brûleur. 5
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12. Dispositif selon l'une ou plusieurs des revendications précédentes **caractérisé en ce que** l'échangeur de chaleur (12) est un échangeur à faisceau tubulaire avec admission de gaz de haut en bas, en permettant par conséquent la diffusion du chaleur sur la surface entière du brûleur. 15
13. Dispositif, selon l'une ou plusieurs des revendications précédentes **caractérisé en ce que** l'échangeur de chaleur (12) contient l'ensemble du post-brûleur (8, 9, 10), ce qui permet de récupérer même la chaleur produite par le revêtement de la surface du brûleur par la circulation de l'air à l'intérieur du post-brûleur. 20
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14. Méthode de fonctionnement d'un dispositif, selon l'une ou plusieurs des revendications précédentes, **caractérisée en ce que** le dispositif (1) fourni par la présente invention fonctionne selon cinq étapes: une première étape (F1), dans laquelle a lieu une pré-filtration mécanique des particules grossières; une deuxième étape (F2) pendant laquelle a lieu une ionisation en présence d'oxygène et un mélange; 30
35 une troisième étape (F3) pendant laquelle la collecte de poussières fines a lieu conjointement à la conversion et la post-combustion des gaz avec la précipitation électrostatique; une quatrième étape (F4), pendant laquelle a lieu la post-filtration électrostatique des poussières fines; une cinquième étape pendant laquelle a lieu l'échange de chaleur avec l'environnement extérieur. 40
15. Équipement de réchauffage, tel que poêle/brûleur alimenté en bois, granules, copeaux de bois, graines oléagineuses et généralement en biomasse **caractérisé en ce que** il est muni d'un dispositif (1) économe en énergie/écocompatible qui est réalisé selon l'une ou plusieurs des revendications de 1 à 13. 45
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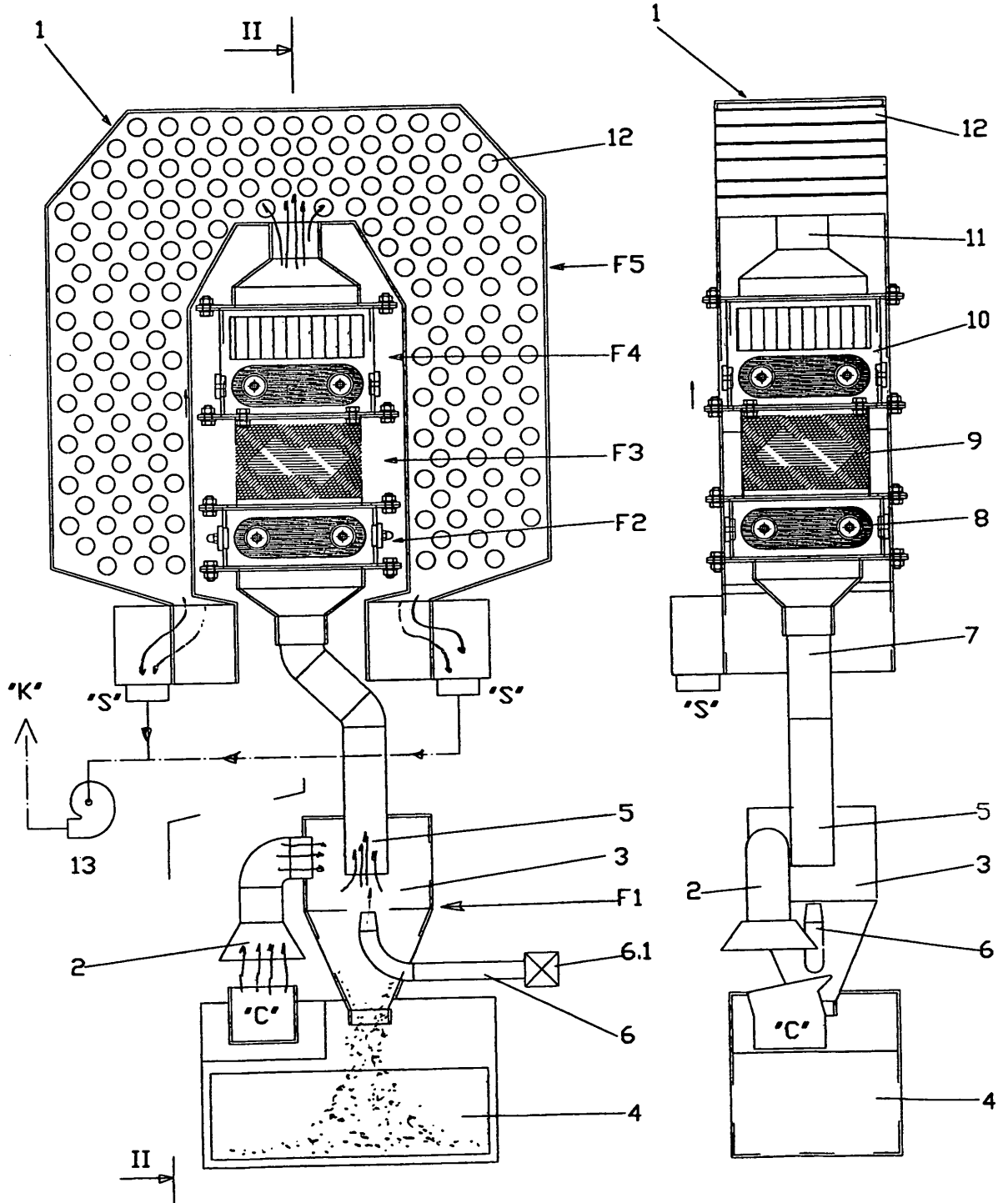
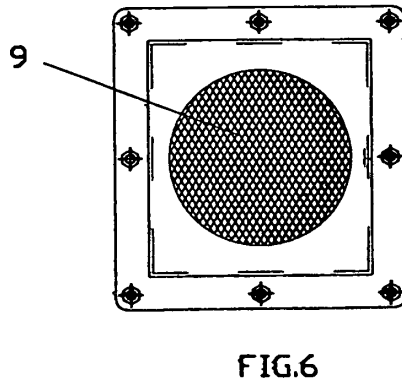
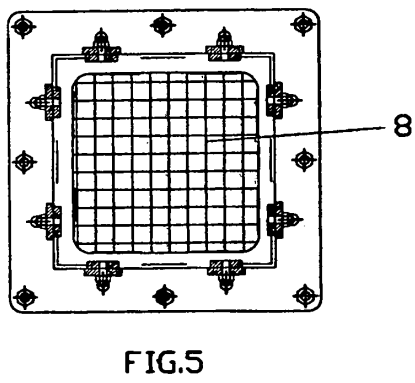
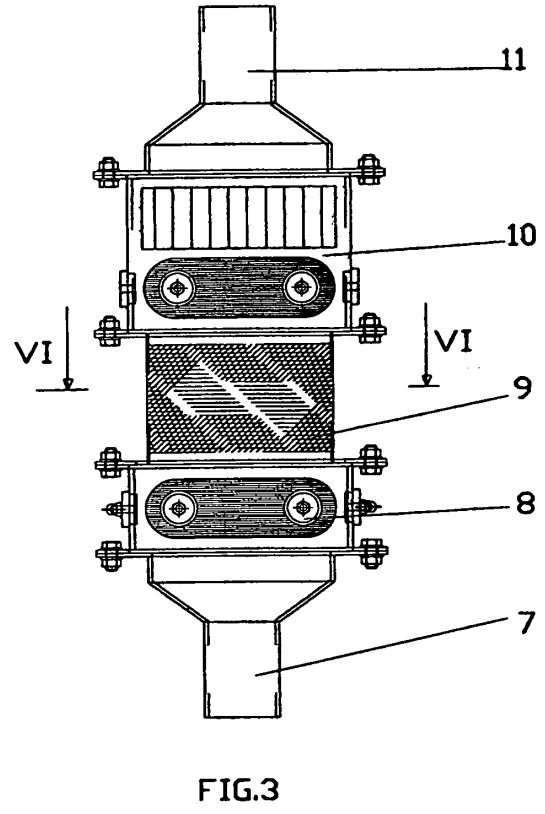
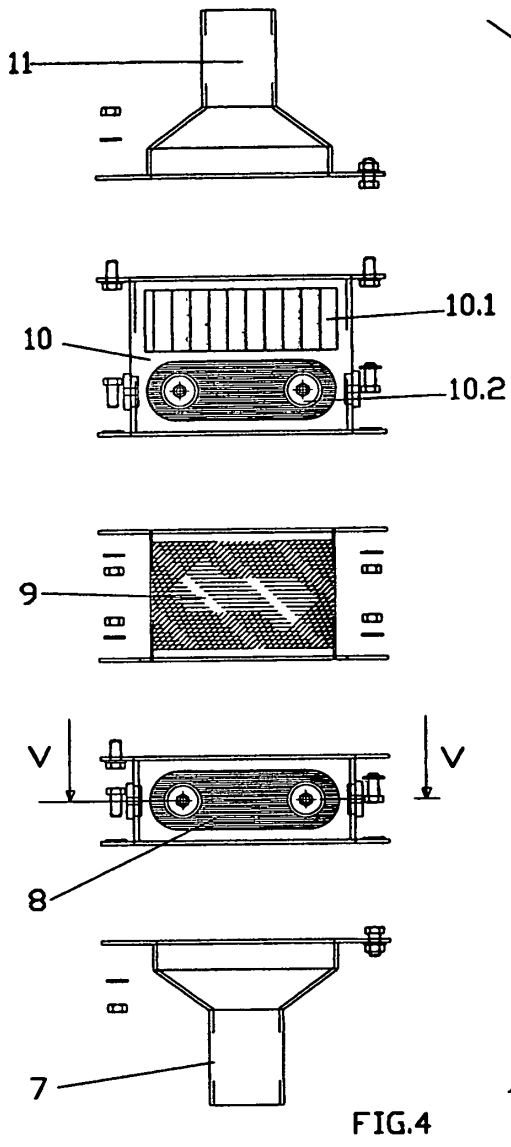


FIG.1

FIG.2



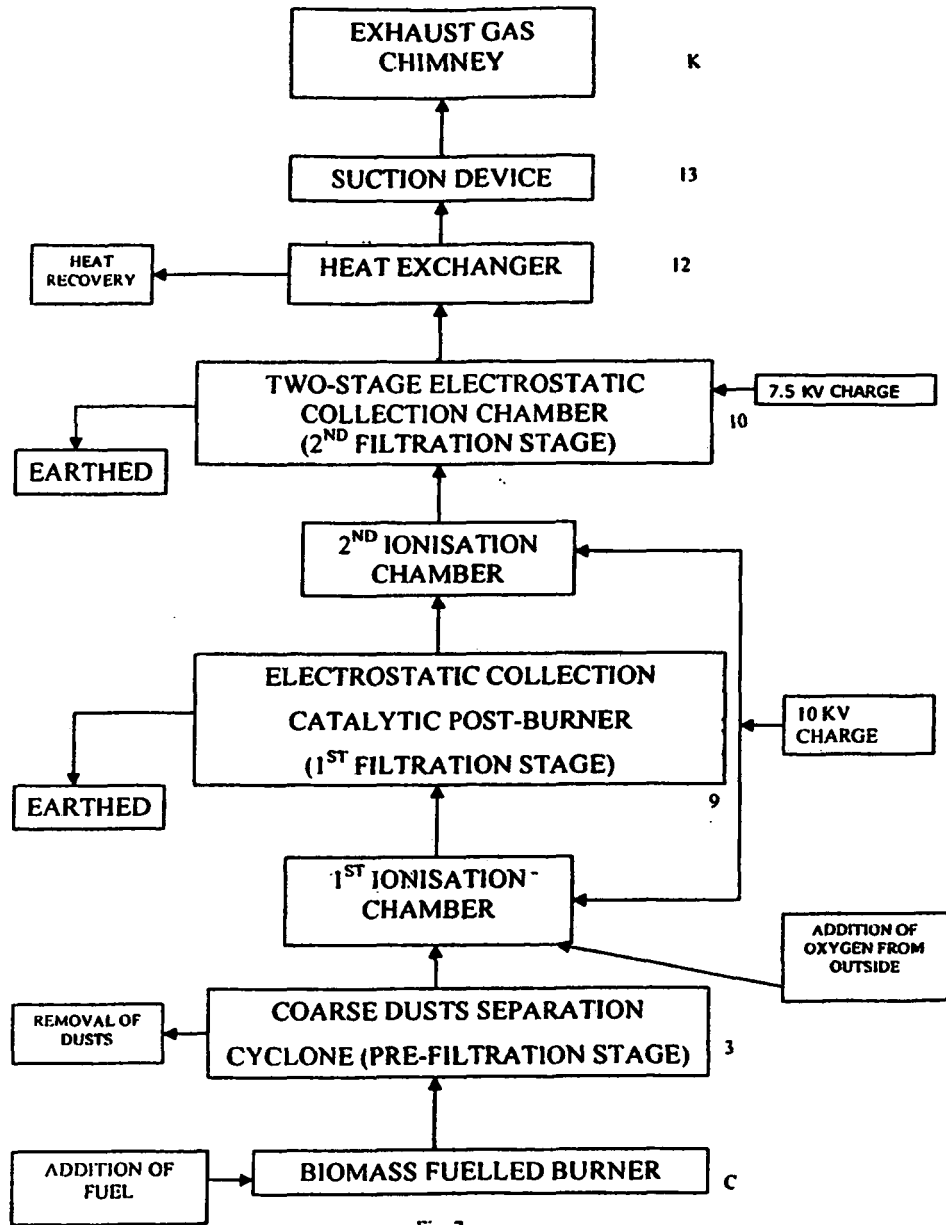


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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