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(71) Applicant: ABB ALSTOM POWER INC. [US/US]; 2000 Day Hill Road, Windsor, CT 06095 (US).

(72) Inventor: COHEN, Mitchell, B.; 19 Rustic Lane, West Hartford, CT 06017 (US).

(74) Agents: WARNOCK, Russell, W. et al.; ABB Alstom Power, Patent Services, 2000 Day Hill Road, Windsor, CT 06095 (US).

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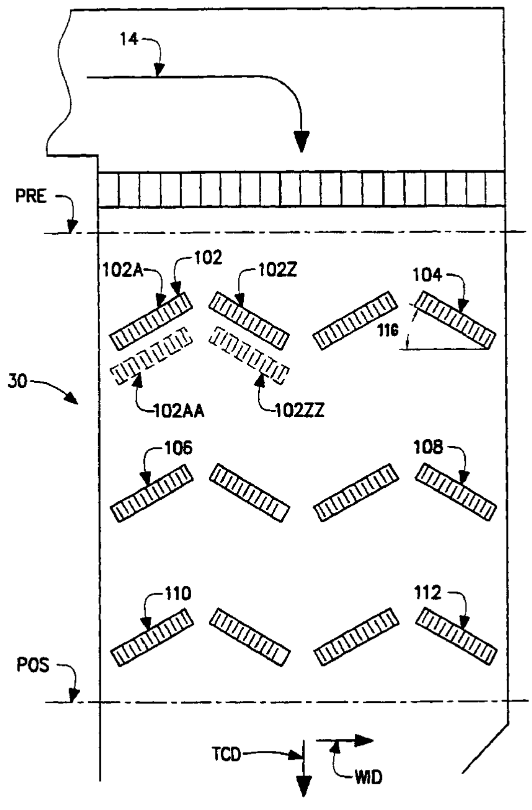
(54) Title: SELECTIVE CATALYTIC REDUCTION SYSTEM FOR A FOSSIL FUEL-FIRED FURNACE OPERATION



(57) Abstract: A selective catalytic reduction system for catalytic treatment of flue gas generated during combustion of fuel in a fossil fuel-fired furnace (10) includes a chamber (30) through which the flue gas flows. The selective catalytic reduction system also includes at least one chevron module assembly (102, 104, 106, 108, 110, 112) disposed in chamber (30). The chevron module assembly (102) has a first group of catalytic surfaces (120) supported between a first leading ends (124) and a first trailing end (122) and a second group of catalytic surfaces (120) supported between a second leading end (126) and a second trailing end (128), the trailing ends (122, 128) being spaced from one another in a width direction perpendicular to the gas flow direction and the pair of leading ends (124, 126) being disposed intermediate the pair of trailing ends (122, 128) relative to the width direction and more upstream than the trailing ends (122, 128) relative to the gas flow direction.

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SELECTIVE CATALYTIC REDUCTION SYSTEM FOR A FOSSIL FUEL-FIRED FURNACE OPERATION

BACKGROUND OF THE INVENTION

This invention relates to a selective catalytic reduction system for operation with a fossil fuel-fired furnace which advantageously permits savings of space, material and operating costs.

In recent years oxides of nitrogen, also known as NO_X, have been implicated as one of the gaseous emissions contributing to the generation of acid rain and smog. One post-combustion process for the lowering of NO_X emissions is that of selective catalytic reduction (SCR). Selective catalytic reduction systems use a catalyst and a reactant such as ammonia gas, NH_3, to dissociate NO_X to molecular nitrogen, N_2, and water vapor. A utility steam generating power plant having, for example, a fossil fuel-fired furnace may utilize selective catalytic seduction (SCR) as a NO_X reduction technique. The furnace typically comprises a furnace volume in fluid communication with a backpass volume. Combustion of hydrocarbon fuels occurs within the furnace volume creating hot flue gases that rise within the furnace volume giving up a portion of their energy to the working fluid of a thermodynamic steam cycle. The flue gases are then directed to and through the backpass volume wherein they give up additional energy to the working fluid. Upon exiting the backpass volume the flue gases are directed via a gas duct through a selective catalytic reduction chamber and thence to an air preheater and flue gas cleaning systems thence to the atmosphere via a stack.

In a typical SCR system, at some point in the gas duct after the flue gas stream exits the backpass volume and upstream of the SCR chamber, a reactant, possibly ammonia, in a gaseous form, or a urea/water solution is introduced into, and encouraged to mix with, the flue gas stream. The reactant/flue gas mixture then enters the SCR chamber wherein the catalytic reductions take place between the reactant/flue gas mixture and the catalytic material. The introduction of the ammonia or urea into the flue gas stream is typically achieved by the use of injector nozzles located at either the periphery of the gas duct, or immersed within the flue gas stream.

The operation of an SCR system is optimized by positioning the SCR system at a location which is most suitable from a thermodynamic point of view. However, the placement and internal arrangement of an SCR system at such a location must accommodate the physical space constraints imposed by other structures of the power plant. In a relatively high dust, hot-side application, for example, it is often preferable to position the SCR reactor chamber between an economizer and an air pre-heater. In such an application, the SCR reaction chamber typically includes multiple layers of solid catalytic material lying within the path of the flue gas stream. A common arrangement in a so-called downflow reaction chamber in which the SCR reaction chamber is at the outlet of the economizer and above the air pre-heater is to dispose the layers or modules of catalytic material horizontally across the full reactor chamber (horizontal) cross-section. Since the actual flue gas velocities for such SCR systems are often as low as one-third the flue gas velocities in boiler ductwork designs, the cross section of the SCR reactor chamber must necessarily be relatively large. Consequently, the in line space limitations between the economizer and the gas inlet to the air pre-heater present a significant challenge in accommodating the SCR reactor chamber in an inline location between these structures. This is especially true for retrofit applications which may present an arrangement in which the air pre-heater is located relatively close to the rear pass of the furnace. Thus, the need exists for a SCR system which has reduced space and material requirements so as to facilitate the inclusion of such systems in new power plant installations and, additionally, to economically expand the range of existing power plant installations in which such systems may be retrofitted.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a new and improved selective catalytic reduction system for operation with a fossil fuel-fired furnace which advantageously permits savings of space, material and operating costs.

It is also an object of the present invention to provide such a new and improved selective catalytic reduction system for operation with a fossil fuel-fired furnace which advantageously reduces the height requirement between layers of catalytic surfaces.

According to one aspect of the present invention, there is provided a selective catalytic reduction chamber for catalytic treatment of flue gas generated during combustion of fuel in a fossil fuel-fired furnace. The selective catalytic reduction chamber includes a chamber having an imaginary pre-treatment threshold across which the flue gas flows in a threshold crossing direction perpendicular to the imaginary pre-treatment threshold and an imaginary post-treatment threshold downstream of, and parallel to, the imaginary pre-treatment threshold across which the flue gas flows after catalytic treatment. The selective catalytic reduction chamber also includes at least one chevron module assembly disposed intermediate the imaginary pre-treatment threshold and the post-treatment threshold. The chevron module assembly defines an apex and having a first group of catalytic surfaces supported between the apex and a first trailing ends and a second group of catalytic surfaces supported between the apex and a second trailing end, the trailing ends being spaced from one another in a width direction perpendicular to the threshold crossing direction and the apex being disposed intermediate the pair of trailing ends relative to the width direction and more upstream than the trailing ends relative to the threshold crossing direction.

According to further features of the one aspect of the present invention, each catalytic surface of the upstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the upstream treatment module are disposed relative to one another such that there overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough. Also, each catalytic surface of the downstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the downstream treatment module are disposed relative to one another such that there overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough. Additionally, it is preferred that the upstream treatment module is disposed at an acute angle with respect to the width direction.

According to another aspect of the present invention, there is provided a selective catalytic reduction chamber for catalytic treatment of flue gas generated during combustion of fuel in a fossil fuel-fired furnace. The selective catalytic reduction chamber includes a chamber having an imaginary pre-treatment threshold across which the flue gas flows in a threshold crossing direction perpendicular to the imaginary pre-treatment threshold and an imaginary post-treatment threshold downstream of, and parallel to, the imaginary pre-treatment threshold across which the flue gas flows after catalytic treatment. The selective catalytic reduction chamber includes a set of treatment modules including an upstream treatment module and a downstream treatment module each supporting a plurality of catalytic surfaces for contact with flue gas to thereby effect catalytic treatment of the flue gas. The upstream treatment module of the one associated pair of treatment modules and the upstream treatment module of the another associated pair of treatment modules form a chevron module assembly disposed intermediate the imaginary pre-treatment threshold and the post-treatment threshold. The chevron module assembly defines an apex and having a first group of catalytic surfaces supported between the apex and a trailing end of one of the upstream treatment modules and a second group of catalytic surfaces supported between the apex and a trailing end of the other upstream treatment module, the trailing ends being spaced from one another in a width direction perpendicular to the threshold crossing direction and the apex being disposed intermediate the pair of trailing ends relative to the width direction and more upstream than the trailing ends relative to the threshold crossing direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic front elevational view of a fossil fuel-fired steam generating power plant including a fuel/air firing system, a furnace volume, a horizontal pass, a backpass volume, and the preferred embodiment of the selective catalytic reduction chamber of the present invention;

Figure 2 is an enlarged elevational view of the preferred embodiment of the selective catalytic reduction chamber of the present invention shown in Figure 1; and

Figure 3 is an enlarged elevational view of a representative chevron module assembly of catalytic surfaces of the preferred embodiment of the selective catalytic reduction chamber of the present invention shown in Figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1 there is depicted a generalized schematic diagram in the nature of a side elevation view of a fossil-fuel fired furnace of a steam generating power plant, generally designated by reference numeral 10, and associated structures including the preferred embodiment of the selective catalytic reduction system of the present invention. For a more detailed description of the nature of the construction and the mode of operation of a fossil-fuel fired furnace such as the fossil-fuel fired furnace 10, one may reference U.S. Patent No. 4,719,587, which issued on Jan. 12, 1987 to F. J. Berte and which is assigned to the same assignee as the present patent application.

Referring further to Figure 1, the fossil-fuel fired furnace 10 includes a furnace volume, generally designated by reference numeral 12. It is within the furnace volume 12 of the fossil-fuel fired furnace 10 that, in a manner well known to those skilled in the art, combustion of fuel and air is initiated. The hot gases that are produced from this combustion, commonly referred to as flue gases 14 and which may act as a heat exchange medium, rise upwardly within the furnace volume 12 and give up heat to the working fluid of a thermodynamic steam cycle. The working fluid passes through the furnace waterwall tubes 16 which in a conventional manner line all four walls of the furnace volume 12. The flue gases 14 then exit the furnace volume 12 through a horizontal pass , generally designated by reference numeral 18. The horizontal pass 18 in turn leads to a backpass volume, generally designated by reference numeral 20. The upper segment of the furnace volume 12 as well as the horizontal pass 18 and the backpass volume 20 commonly contain other heat exchange surfaces 22, 24, 26 for superheating and reheating steam or heating feedwater in a manner well known to those skilled in the art. Thereafter, the steam generated in the thermodynamic steam cycle commonly is made to flow to a turbine (not shown), which forms one component of a turbine/generator set (not shown). The steam provides the motive power to drive the turbine which thence drives the generator. The generator is, in known fashion, cooperatively associated with the turbine such that electricity is produced thereby.

With further reference to Figure 1, the aforesaid flue gases 14, after passing through the backpass volume 20 and giving up heat to the heat exchange surfaces 24, 26 therein, are directed via flue gas ductwork 28 through a selective catalytic reduction chamber 30 and thence to an air preheater (not shown), flue gas cleaning systems (not shown), a stack (not shown) and are then vented to the atmosphere.

Referring further to Figure 1 there is also depicted a schematic representation of a means, generally designated by the numeral 32, for supplying fuel and air to the furnace volume 12. The fuel and air supply means 32 consists of various ducts 34 so designed and constructed as to transport fuel and air, separately or if need be in combination, from a fuel source 36 and an air source 38 to a main windbox 40 thence therethrough to the furnace volume 12. The air may also be directed to a set of separated overfire air (SOFA) windboxes 42, and thence therethrough to the furnace volume 12 so as to complete the aforesaid combustion. For a more detailed description of the nature of construction and the mode of operation of the fuel and air supply means, one may reference U.S. Patent No. 5,315,939, which issued on May 31, 1994 to M. Rini et al. and which is assigned to the same assignee as the present patent application.

Continuing further in Figure 1 there is also depicted a schematic representation of a means, generally designated by the reference numeral 44, for supplying a reactant to the flue gas 14 flowing through the flue gas ductwork 28. The reactant supply means 44 includes a reactant source 46 and a reactant grid 48 so designed and constructed, in combination, as to transport the reactant from the reactant source 46 to the flue gases 14 for mixture therewith. The flue gas/reactant mixture then flows to the selective catalytic reduction chamber 30 wherein it undergoes selective catalytic reduction.

With further reference now to Figure 2, which is an enlarged elevational view of a portion of the fossil fuel-fired furnace shown in Figure 1, the preferred embodiment of the selective catalytic reduction chamber 30 of the present invention will be described in greater detail. The selective catalytic reduction chamber 30 has an imaginary pre-treatment threshold PRE across which the flue gas flows in a threshold crossing direction TCD perpendicular to the imaginary pre-treatment threshold. The imaginary pre-treatment threshold PRE may be defined, for example, by the reactant grid 48. The selective catalytic reduction chamber 30 also includes an imaginary post-treatment threshold POS downstream of, and parallel to, the imaginary pre-treatment threshold PRE across which the flue gas flows after catalytic treatment within the selective catalytic reduction chamber 30.

The selective catalytic reduction chamber 30 includes a set of treatment modules disposed intermediate the imaginary pre-treatment threshold PRE and the imaginary post-treatment threshold POS for contacting the flue gas flowing through the selective catalytic reduction chamber 30 so as to effect catalytic treatment of the flue gas. The set of treatment modules includes an upper elevation of treatment modules including a first upper chevron module assembly 102 and a second upper chevron module assembly 104, a mid level elevation of treatment modules including a first mid-level chevron module assembly 106 and a second mid-level chevron module assembly 108, and a lower elevation of treatment modules including a first lower chevron module assembly 110 and a second lower chevron module assembly 112.

Each chevron module assembly 102 –112 is comprised of two associated pairs of treatment modules. The first upper chevron module assembly 102 includes an associated pair of treatment modules 102A and 102AA and another associated pair of treatment modules 102Z and 102ZZ. The second upper chevron module assembly 104 includes an associated pair of treatment modules 104A and 104AA and another associated pair of treatment modules 104Z and 104ZZ. The first mid-level chevron module assembly 106 includes an associated pair of treatment modules 106A and 106AA and another associated pair of treatment modules 106Z and 106ZZ. The second mid-level chevron module assembly 108 includes an associated pair of treatment modules 108A and 108AA and another associated pair of treatment modules 108Z and 108ZZ. The first lower chevron module assembly 110 includes an associated pair of treatment modules 110A and 110AA and another associated pair of treatment modules 110Z and 110ZZ. The second lower chevron module assembly 112 includes an associated pair of treatment modules 112A and 112AA and another associated pair of treatment modules 112Z and 112ZZ.

The configuration of an elevation of the chevron treatment module assemblies 102 –112 will now be described with respect to the upper elevation of chevron module assemblies comprising the first upper chevron module assembly 102 and the second upper chevron module assembly 104, it being understood that the other elevations of chevron module assemblies are similarly configured. Also, in connection with the description of the exemplary elevation of the chevron module assemblies, the configuration of a respective one of the chevron module assemblies will now be described with respect to one of the chevron module assemblies of the upper elevation of chevron module assemblies (namely, with respect to the first upper chevron module assembly 102), it being understood that the other chevron module assemblies 104 – 112 are similarly configured. With reference now to Figure 3, which is an enlarged plan view of the first upper chevron module assembly 102, it can be seen that this chevron module assembly, which, like the other chevron module assemblies 104 – 112, is disposed intermediate the imaginary pre-treatment threshold PRE and the post-treatment threshold POS, is configured with an overall slope shape. This overall slope shape advantageously permits the cross-sectional area of the selective catalytic reduction chamber 30 to be minimized, as will be explained in more detail shortly.

The first upper chevron module assembly 102 includes, as previously noted, the associated pair of treatment modules 102A and 102AA and another associated pair of treatment modules 102Z and 102ZZ. However, attention will now be drawn to the relationship of the upstream one of the associated pair of treatment modules 102A and 102AA – specifically, the treatment module 102A – and the upstream one of the other associated pair of treatment modules 102Z and 102ZZ – specifically, the treatment module 102Z. The treatment modules 102A and 102Z, as well as the other respective two upstream treatment modules and the respective two downstream treatment modules of each chevron module assembly 102 – 112, are slope counterpart treatment modules which are cooperatively disposed relative to one another in a manner which permits the cross sectional area of the selective catalytic reduction chamber 30 to be minimized while effectively intercepting the flue gas flowing through the selective catalytic reduction chamber 30 for catalytic treatment thereof.

The treatment modules 102A and 102Z each has a perimeter with an overall rectangular shape. The treatment module 102A is oriented with its longitudinal extent at an acute angle 114 with respect to the threshold crossing direction TCD. The acute angle 114 is preferably between thirty (30) to sixty (60) degrees. However, it is to be understood that the selected angular orientation of a treatment module will ultimately be determined in consideration of the nature of the ash characteristics and the severity of the ash loading of the particular fossil fuel-fired furnace in which the treatment module is installed while taking into consideration as well the mechanism that the greater the slope angles of the treatment modules, the smaller will be the cross section of the selective catalytic reduction chamber 30. The other one of each respective group of slope counterpart treatment modules is preferably oriented with respect to its counterpart such that the counterpart treatment modules slope in opposite senses from one another. For example, the treatment module 102Z is oriented with its longitudinal extent at an acute angle 116 with respect to the threshold crossing direction TCD but in a reverse sense than the acute angle 114 of the treatment module 102A. Depending upon the value of the acute angle 114 of the treatment module 102A in the preferred embodiment, which, as noted, is between thirty (30) to sixty (60) degrees, the acute angle of 116 of the treatment module 102Z is preferably established at a reverse acute value. For example, if the acute angle 114 of the treatment module 102A is thirty (30) degrees, then the acute angle 116 of the treatment module 102Z is preferably established as a reverse acute angle of thirty (30) degrees (in other words, an angle of one hundred and fifty (150) degrees [180 degrees – 30 degrees = 150 degrees] as measured in the same sense as the measurement of the acute angle 114 of the treatment module 102A).

As a result of the reverse sense orientation of each respective group of slope counterpart treatment modules, each respective group defines an apex such as, for example, the apex 118 formed between the slope counterpart treatment modules 102A and 102Z, shown in broken lines in Figure 3. Groups of catalytic surfaces are supported by the slope counterpart treatment modules between the apex defined thereby and the trailing ends of the treatment modules. Thus, a first group of catalytic surfaces 120 are supported by the treatment module 102A between its leading end, hereinafter designated as 122 and its trailing end, hereinafter designated as the trailing end 124, and a second group of the catalytic surfaces 120 are supported by the treatment module 102Z between its leading end, hereinafter designated as the leading end 126, and its trailing end, hereinafter designated as the trailing end 128.

The catalytic surfaces 120 of the preferred embodiment of the selective catalytic reduction chamber 30 are, as shown in Figure 3, planar in shape and are arranged relative to one another such that the flow of flue gas relative to the catalytic surfaces is parallel to the overall longitudinal extent of these surfaces – in the case of the planar catalytic surfaces 120, this means parallel to the planes of the surfaces. This is achieved by the arrangement of the catalytic surfaces 120 in parallel orientation to one another within each treatment module. Regardless of their shape, it is preferable that the catalytic surfaces be oriented such that the flue gas can flow in a manner which does not promote an increase in pluggage susceptibility, erosion, or pressure drop. Thus, each catalytic surface 120 of an upstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the upstream treatment module are disposed relative to one another such that their overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough. Also, each catalytic surface 120 of each downstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the downstream treatment module are disposed relative to one another such that their overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough.

In each respective grouping of slope counterpart treatment modules, the trailing ends of the treatment modules are spaced from one another in a width direction WID perpendicular to the threshold crossing direction and the apex is disposed intermediate the pair of trailing ends relative to the width direction WID and more upstream than the trailing ends relative to the threshold crossing direction. Thus, the trailing ends 122 and 128 of the treatment modules 102A and 102Z, respectively, are spaced from one another in the width direction WID perpendicular to the threshold crossing direction TCD and the apex 118 is disposed intermediate the pair of trailing ends 122, 128 relative to the width direction WID and more upstream than the trailing ends 122, 128 relative to the threshold crossing direction TCD.

Attention will now be drawn to the relationship of each respective upstream or downstream treatment module of a respective associated pair of treatment modules in a chevron module assembly 102 – 112 to the other treatment module in the respective chevron module assembly. With reference to Figure 3, it can be seen that the two respective associated pairs of treatment modules of the chevron module assembly 102 – namely, the associated pair of treatment modules 102A and 102AA and the other associated pair of treatment modules 102Z and 102ZZ - are cooperatively disposed relative to one another in a manner which permits the cross sectional area of the selective catalytic reduction chamber 30 to be minimized while effectively intercepting the flue gas flowing through the selective catalytic reduction chamber 30 for catalytic treatment thereof. With respect to the treatment module 102A, which is the upstream one of the associated pair of treatment modules 102A, 102AA, its leading end 124 is disposed more upstream than its trailing end 122 relative to the threshold crossing direction TCD. The downstream one of the associated pair of treatment modules 102A, 102AA is disposed downstream of the upstream treatment module 102A relative to the threshold crossing direction TCD such that the upstream and downstream modules of the one associated pair of treatment modules 102A, 102AA at least partially overlap one another as viewed in the width direction WID perpendicular to the threshold crossing direction TCD. Moreover, the leading end of the downstream treatment module 102AA of the one associated pair of treatment modules 102A, 102AA, hereinafter designated as the leading end 130, is disposed more upstream than both its trailing end, hereinafter designated as the trailing end 132, and the trailing end 122 of the upstream treatment module 102A relative to the threshold crossing direction TCD. Specifically, it can be seen that the lower corner of the leading end 130 of the downstream treatment module 102AA is spaced by an upstream spacing 134 from the lower corner of the trailing end 132 of the downstream treatment module 102AA and spaced by an upstream spacing 136 from the lower corner of the trailing end 122 of the upstream treatment module 102A.

The present invention contemplates that soot blowers and catalyst removal steel can be arranged for maximum effectiveness in performing their respective functions on the chevron module assemblies. Additionally, it is contemplated that vaning and flow directional devices can be provided to maintain uniformity of flow across the inlet face of the treatment modules. For example, as seen in Figure 3, a plurality of vane modules 138, only one of which is shown, may be provided to intercept the gas flow immediately upstream of the treatment modules and orient the gas flow for parallel flow between the catalytic surfaces 120. Each vane module 138 may comprise a plurality of channels 140 which have vertical inlets for receiving the downwardly flowing flue gas and elongate body portions aligned parallel to the catalytic surfaces 120 for re-orienting the intercepted flue gas into streams parallel to the catalytic surfaces 120.

The improved selective catalytic reduction system of the present invention thus beneficially permits a reduction in the reactor chamber cross-sectional area as compared to conventional reactor chambers while maintaining the required NO_X removal efficiency, ammonia slip, and overall system pressure drop.

While a preferred embodiment of my invention has been shown, it will be appreciated by those skilled in the art that modifications may readily be made thereto. I, therefore intend by the appended claims to cover any modifications alluded to herein as well as to all modifications that fall within the true spirit and scope of my invention.

I claim:

1. A selective catalytic reduction system for catalytic treatment of flue gas generated by a fossil fuel-fired furnace operable to combust a fossil fuel, comprising:

a chamber having an imaginary pre-treatment threshold across which the flue gas flows in a threshold crossing direction perpendicular to the imaginary pre-treatment threshold and an imaginary post-treatment threshold downstream of, and parallel to, the imaginary pre-treatment threshold across which the flue gas flows after catalytic treatment; and

a set of treatment modules disposed intermediate the imaginary pre-treatment threshold and the imaginary post-treatment threshold, the set of treatment modules including at least one associated pair of treatment modules including an upstream treatment module and a downstream treatment module each supporting a plurality of catalytic surfaces for contact with flue gas to thereby effect catalytic treatment of the flue gas,

the upstream treatment module of the one associated pair of treatment modules supporting a plurality of catalytic surfaces between a leading end and a trailing end thereof, the leading end of the upstream treatment module of the one associated pair of treatment modules being disposed more upstream than its trailing end relative to the threshold crossing direction and

the downstream treatment module of the one associated pair of treatment modules being disposed downstream of the upstream treatment module relative to the threshold crossing direction such that the upstream and downstream modules of the one associated pair of treatment modules at least partially overlap one another as viewed in a width direction perpendicular to the threshold crossing direction, the downstream treatment module of the one associated pair of treatment modules supporting a plurality of catalytic surfaces between a leading end and a trailing end, the leading end of the downstream treatment module being disposed more upstream than both its trailing end and the trailing end of the upstream treatment module relative to the threshold crossing direction.

2. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 1 wherein each catalytic surface of the upstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the upstream treatment module are disposed relative to one another such that their overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough and each catalytic surface of the downstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the downstream treatment module are disposed relative to one another such that their overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough.

3. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 2 wherein the upstream treatment module is disposed at an acute angle with respect to the width direction.

4. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 3 wherein the upstream treatment module is disposed at an acute angle between thirty to sixty degrees with respect to the width direction.

5. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 1 wherein the set of treatment modules includes another associated pair of treatment modules including an upstream treatment module and a downstream treatment module each supporting a plurality of catalytic surfaces for contact with flue gas to thereby effect catalytic treatment of the flue gas, the upstream treatment module of the one associated pair of treatment modules and the upstream treatment module of the another associated pair of treatment modules forming a chevron module assembly disposed intermediate the imaginary pre-treatment threshold and the post-treatment threshold, the chevron module assembly defining an apex and having a first group of catalytic surfaces supported between the apex and a trailing end of one of the upstream treatment modules and a second group of catalytic surfaces supported

between the apex and a trailing end of the other upstream treatment module, the trailing ends being spaced from one another in a width direction perpendicular to the threshold crossing direction and the apex being disposed intermediate the pair of trailing ends relative to the width direction and more upstream than the trailing ends relative to the threshold crossing direction.

6. A selective catalytic reduction system for catalytic treatment of flue gas generated by a fossil fuel-fired furnace operable to combust a fossil fuel, comprising:

a chamber having an imaginary pre-treatment threshold across which the flue gas flows in a threshold crossing direction perpendicular to the imaginary pre-treatment threshold and an imaginary post-treatment threshold downstream of, and parallel to, the imaginary pre-treatment threshold across which the flue gas flows after catalytic treatment; and

at least one chevron module assembly disposed intermediate the imaginary pre-treatment threshold and the post-treatment threshold, the chevron module assembly defining an apex and having a first group of catalytic surfaces supported between the apex and a first trailing end and a second group of catalytic surfaces supported between the apex and a second trailing end, the trailing ends being spaced from one another in a width direction perpendicular to the threshold crossing direction and the apex being disposed intermediate the pair of trailing ends relative to the width direction and more upstream than the trailing ends relative to the threshold crossing direction.

7. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 6 wherein each catalytic surface of the upstream treatment module has a shape which defines an overall planar longitudinal extent and the catalytic surfaces of the upstream treatment module are disposed relative to one another such that their overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough and each catalytic surface of the downstream treatment module has a shape which defines an overall planar longitudinal extent and

the catalytic surfaces of the downstream treatment module are disposed relative to one another such that their overall planar longitudinal extents are generally parallel to one another to thereby form passages between each respective adjacent pair of catalytic surfaces for the flow of flue gas therethrough.

8. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 7 wherein the upstream treatment module is disposed at an acute angle with respect to the width direction.

9. In a fossil fuel-fired furnace, a selective catalytic reduction chamber according to claim 8 wherein the upstream treatment module is disposed at an acute angle between thirty to sixty degrees with respect to the width direction.

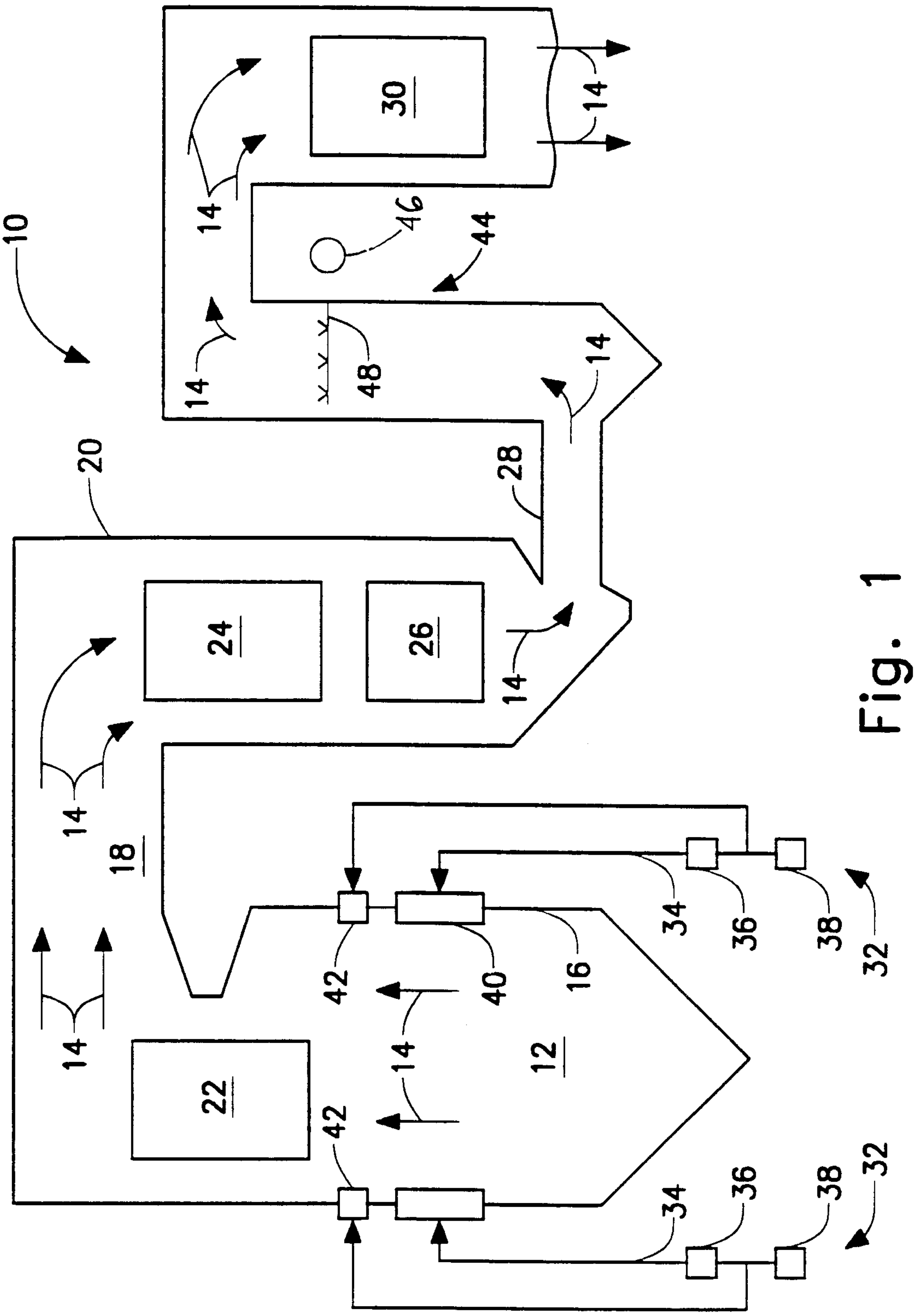
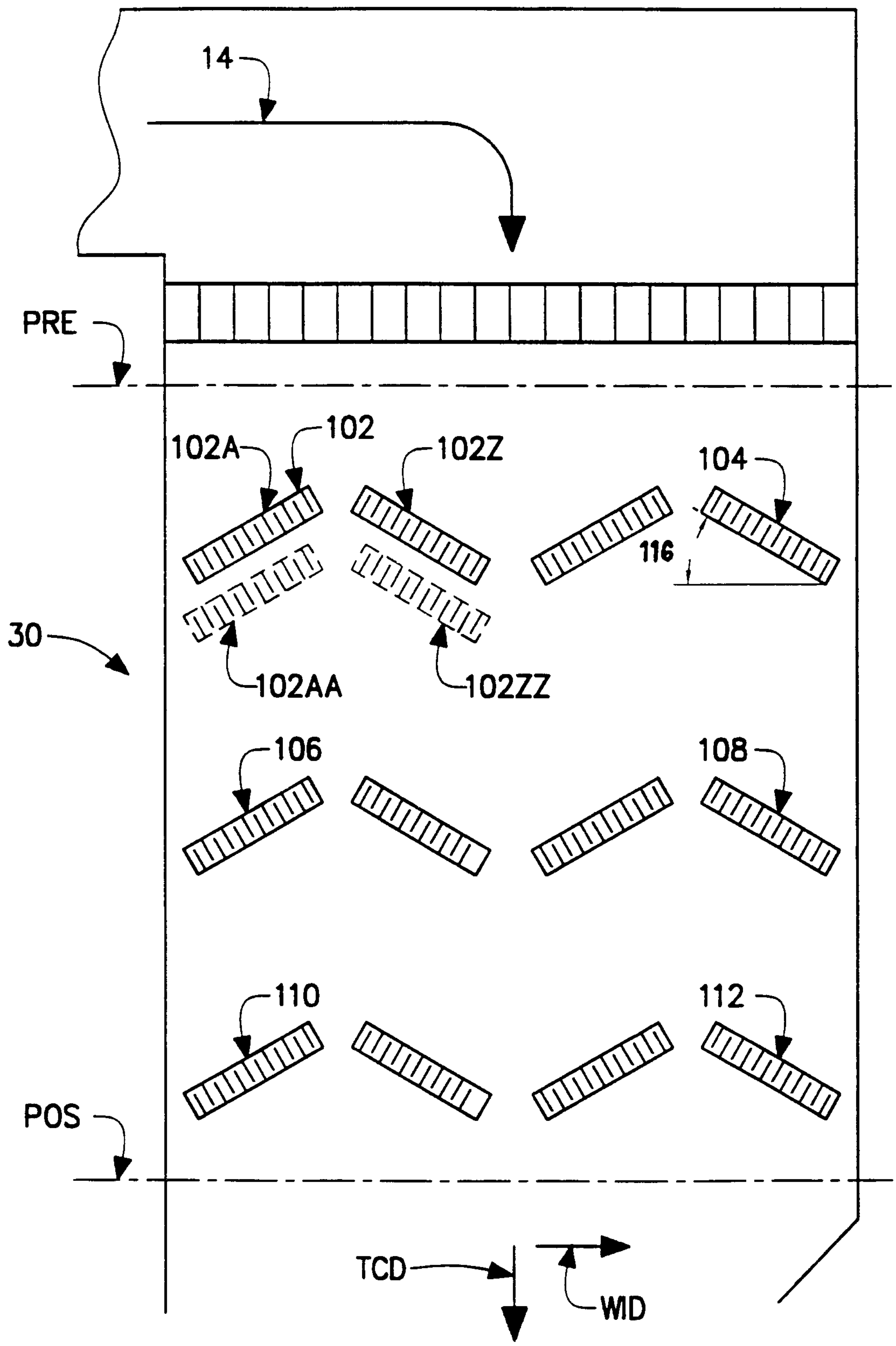


Fig. 1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PRE
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104
116
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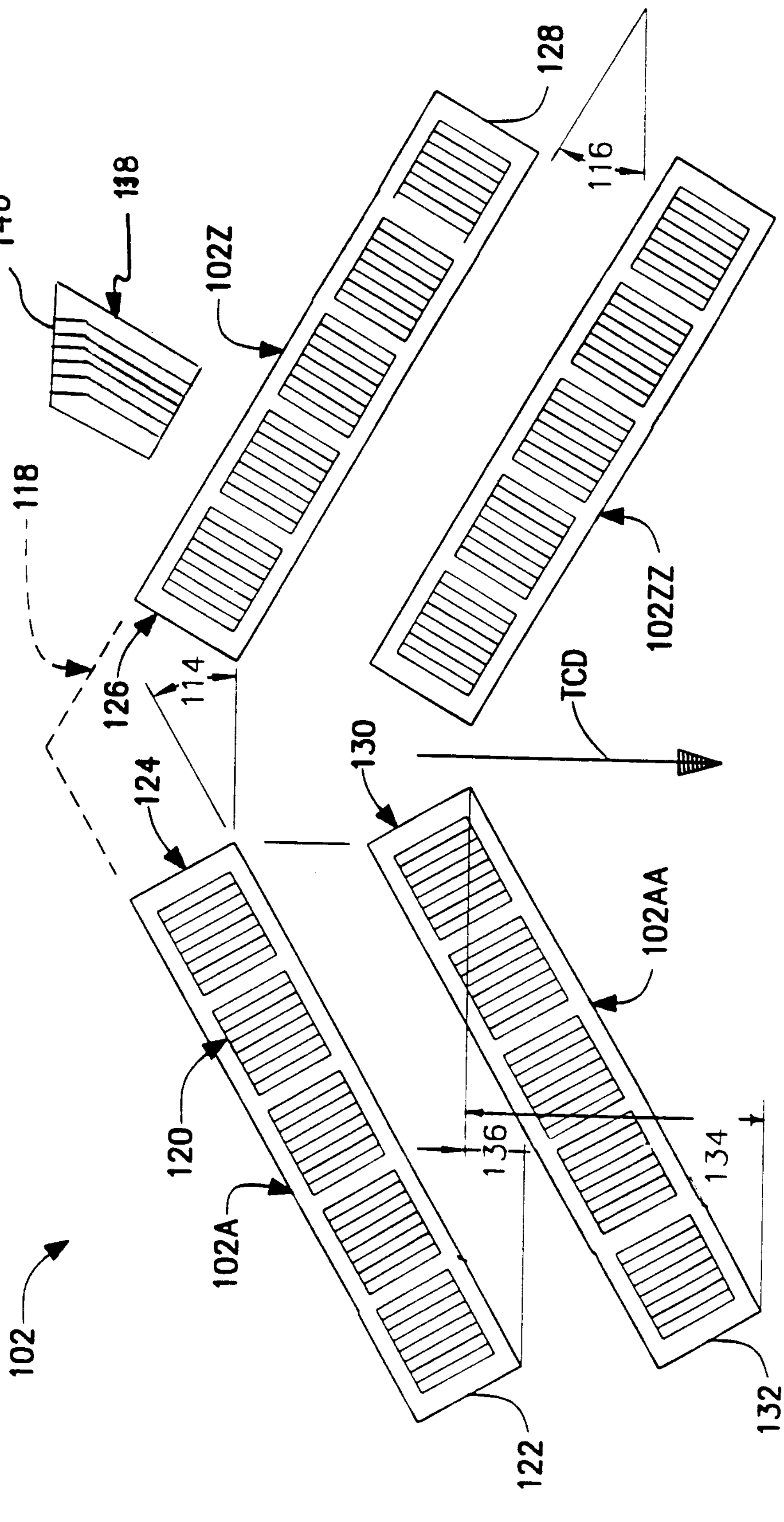
106
108
110
112
POS
TCD
WID

Fig. 2


102
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120
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124
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114
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140
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116
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TCD
130
102AA
136
134
132

Fig. 3

INTERNATIONAL SEARCH REPORT

Int(ional Application No
PCT/US 00/16176

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D53/86 F23J15/02 B01J8/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D F23J B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 35 05 351 A (LINDE AG) 21 August 1986 (1986-08-21) the whole document ---	1-9
X	PATENT ABSTRACTS OF JAPAN vol. 005, no. 160 (C-075), 15 October 1981 (1981-10-15) -& JP 56 089836 A (MITSUBISHI HEAVY IND CO LTD), 21 July 1981 (1981-07-21) abstract & DATABASE WPI Section Ch, Week 198136 Derwent Publications Ltd., London, GB; Class J01, AN 1981-65051D & JP 56 089836 A (MITSUBISHI HEAVY IND CO LTD), 21 July 1981 (1981-07-21) abstract ---	1-9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 October 2000	02/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Eijkenboom, A

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Section Ch, Week 197647 Derwent Publications Ltd., London, GB; Class J04, AN 1976-87531X XP002149337 -& JP 51 112483 A (ASAHI GLASS CO LTD), 4 October 1976 (1976-10-04) abstract; figures 5B,5C	1,3-6,8, 9
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Information on patent family members

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