

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43bis.1)**

To:

see form PCT/ISA/220

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/B2018/056780

International filing date (day/month/year)
05.09.2018

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05.09.2017

International Patent Classification (IPC) or both national classification and IPC
INV. F23D14/02 F23D14/64 F23N5/18

Applicant
JOHN ZINK COMPANY, LLC

1. This opinion contains indications relating to the following items:

- Box No. I Basis of the opinion
- Box No. II Priority
- Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- Box No. IV Lack of unity of invention
- Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- Box No. VI Certain documents cited
- Box No. VII Certain defects in the international application
- Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:



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Date of completion of this opinion

see form PCT/ISA/210

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Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - the international application in the language in which it was filed.
 - a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. forming part of the international application as filed:
 - in the form of an Annex C/ST.25 text file.
 - on paper or in the form of an image file.
 - b. furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. furnished subsequent to the international filing date for the purposes of international search only:
 - in the form of an Annex C/ST.25 text file (Rule 13ter.1(a)).
 - on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713).
4. In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

Box No. IV Lack of unity of invention

1. In response to the invitation (Form PCT/ISA/206) to pay additional fees, the applicant has, within the applicable time limit:
- paid additional fees
 - paid additional fees under protest and, where applicable, the protest fee
 - paid additional fees under protest but the applicable protest fee was not paid
 - not paid additional fees
2. This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is
- complied with
 - not complied with for the following reasons:
see separate sheet
4. Consequently, this report has been established in respect of the following parts of the international application:
- all parts.
 - the parts relating to claims Nos. 1-39

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-39</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	<u>1-31, 33-39</u>
	No: Claims	<u>32</u>
Industrial applicability (IA)	Yes: Claims	<u>1-39</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item IV

Lack of unity of invention

This Authority considers that the application does not meet the requirements of unity of invention and that there are two inventions.

The reasons, for which the inventions are not so linked as to form a single general inventive concept, as required by Rule 13.1 PCT, are as follows:

The common matter linking together the independent claims 1, 9, 25 and 32 is the following:

- primary combustion zone / chamber, implicitly defining also a following secondary combustion (zone)

This common matter does not comprise a single general inventive concept, based on same or corresponding special technical features within the meaning of Rule 13.2 PCT, because low NO_x burner apparatuses and their method of operation having a primary combustion chamber / zone and a secondary combustion zone are disclosed in D1 (US 5,407,345).

D1 discloses a low NO_x burner apparatus (column 1, lines 5, 6). Air is added through an input 25 into a plenum 20 and is mixed in mixing section 40 with fuel entering through fuel input 21 (see figure 1; column 1, line 67 to column 2, line 8). The lean premix enters primary burner section (= chamber) 60, where it is burned (figure 1; column 5, lines 63-65). Secondary fuel gas jets 101 surround the outlet of the primary burner section thus forming a secondary flame section / secondary burning (= secondary combustion zone) (figure 1; column 8, lines 1-11).

Hence, the following separate inventions or groups of inventions are not so linked as to form a single general inventive concept:

claims: 1-24

Method of low NO_x combustion and corresponding burner; a burner tile is surrounded by a furnace environment and a primary combustion zone is defined within the burner tile for a lean, low NO_x first combustion step

claims: 25-39

Method of controlling low NO_x combustion and corresponding burner system, e.g. within a furnace; a primary combustion zone is defined by a burner tile for a lean, low NO_x first combustion step; flow rates are adjusted based on fuel composition and/or adiabatic flame temperature and/or measured NO_x values in the furnace.

Independent claim 1 comprises the non-common feature "furnace environment surrounding the burner tile". Independent claim 9 comprises the equivalent feature "tile wall extending into the furnace", thereby linking claims 1 and 9 to form one single invention.

This non-obvious feature provides the technical effect of superior premixing the secondary fuel with the flue gases in the furnace (due to the long mixing distance caused by the extending wall) and solves the objective technical problem of avoiding fuel rich zones in the secondary combustion zone.

Independent claim 25 comprises the non-common features "determining the composition of the primary and secondary fuel, determining the adiabatic flame temperatures and determining the required excess air quality required to produce a certain NO_x amount". Independent claim 32 comprises the "overlapping" non-common features "computer processing system to adjust fuel flow rates .. based on the fuel composition and/or the adiabatic flame temperature and/or the measured NO_x emissions from the furnace, thereby linking claims 25 and 32 to form one single invention. This non-obvious feature provides the technical effect of superior flame(s) temperature(s) control and solves the objective technical problem of reducing NO_x emissions.

Hence, the claims comprise neither the same, nor corresponding special technical features, so the technical relationship between the subject matter of the claims required by Rule 13.2 PCT is lacking and the claims are not so linked as to form a single general inventive concept as required by Rule 13.1 PCT.

Consequently the application does not meet the requirement for unity of invention.

The application relates to a plurality of inventions, or groups of inventions, in the sense of Rule 13.1 PCT. They have been divided as defined above. If the applicant pays additional fees for one (or more) not yet searched group(s) of invention(s), then the further search(es) may reveal further prior art that gives evidence of a further lack of unity 'a posteriori' within one (or more) of the not yet searched group(s). In such a case only the first invention in this (each of these) group(s) of inventions, which is considered to lack unity of invention, will be the subject of a search. No further invitation to pay further additional fees will be issued. This is because Article 17(3)(a) PCT stipulates that the ISA shall establish the International Search Report on those parts of the international application which relate to the invention first mentioned in the claims ('main invention') and for those parts which relate to inventions in respect of which the additional fees were paid. Neither the PCT nor the PCT guidelines provide a legal basis for further invitations to pay further additional search fees (W17/00, point

11 and W1/97, points 11-16). In such a case the non-searched claims may be the subject of one or more divisional applications after the application has entered the regional phase before the EPO (see W18/07, point 26).

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 US 5 407 345 A (ROBERTSON THOMAS [US] ET AL) 18 April 1995 (1995-04-18)
- D3 US 5 605 452 A (ROBERTSON THOMAS F [US] ET AL) 25 February 1997 (1997-02-25)
- D2 EP 0 562 710 A2 (ZINK CO JOHN [US]) 29 September 1993 (1993-09-29)

1 Independent Claim 1

- 1.1 D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses a method of discharging fuel and an amount of air into a furnace space wherein fuel is burned such that flue gases having low NO_x content and low CO content are formed therefrom, namely:

A method of discharging fuel and an amount of air into a furnace space (column 1, lines 5, 6; figure 1; column 8, lines 7-9 for furnace) wherein the fuel is burned such that flue gases having low NO_x content (see above) and low CO content (implicitly disclosed through lines 12-15 in combination with the high oxygen content in the primary combustion zone, see e.g. column 1, lines 54-58) are formed therefrom, the method comprises:
mixing a first portion of the fuel and substantially all of the air to form a lean primary fuel-air mixture (figure 1: sole air input 25; primary fuel input 21, mixing section 40);
discharging the lean primary fuel-air mixture into the furnace space within a primary combustion zone (figure 1: primary burner section 60; column 4, lines 59, 60) defined by a burner tile (figure 1, item 91; column 7, lines 58, 59);
burning the primary fuel-air mixture in the primary combustion zone to

produce a flame and thus generated flue gases, wherein the primary combustion zone has a first end and a second end (figure 1), and the lean primary fuel-air mixture is introduced so that the flame is anchored adjacent the first end (column 4, line 59 to column 5, line 9) and the generated flue gases are discharged into the furnace environment at the second end (figure 1; column 5, lines 63-65).

1.2 The subject-matter of claim 1 therefore differs from this known method in that there is a furnace environment surrounding the burner tile and is therefore new (Article 33(2) PCT).

1.3 The problem to be solved by the present invention may be regarded as how to avoiding fuel rich zones in the secondary combustion zone.

1.4 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

1.4.1 D1 discloses the secondary fuel being injected through the burner tile at the outlet of the primary combustion zone.

The mounting of the tile protruding into the furnace would NOT solve the technical problem.

1.4.2 D1 features a massive tile and teaches the advantages of heat storage; the figures seem to show a mounting flange. The skilled man - knowing that high temperature furnaces employing tile type burners typically have a refractory insulation - would provide a flush mounting in order to embed the burner tile in the refractory (thereby using additional heat storage) rather than exposing the tile to the changing temperatures (e.g. short interruptions of operation) of the furnace space.

1.4.3 Although D2 teaches a burner with an extending tile wall (see figures 1, 2) the skilled man is not prompted to expose the massive tile of D1, because

- exposing the tile of D1 would not solve the problem (see 1.4.1)
- exposing the tile of D1 counteracts the teaching of D1 (see 1.4.2)
- the tile of D2 is directed to anchoring the flame, whereas D1 teaches to complete the primary combustion within the primary combustion zone.

problem (see 1.4.1)

2 Dependent Claims 2-8

2.1 Claims 2-8 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

3 Independent Claim 9

3.1 Furthermore, the below-mentioned lack of clarity notwithstanding, the subject-matter of claim 9 is new and does involve an inventive step in the sense of Article 33(3) PCT.

3.2 D1, which is considered to represent the most relevant state of the art, discloses a fuel gas burner (see figure 1; cited passages; 1.1) from which the subject-matter of claim 9 differs in that

A: a burner tile wall extends into the furnace

B: a plurality of flame holders are located within the (primary) combustion chamber

C: a primary tube is an ignition unit

D: the secondary fuel tips are operably associated with the burner apparatus, such that the secondary fuel gas is injected from outside of the burner tile.

3.3 The problem to be solved by the present invention may be regarded as how to avoiding fuel rich zones in the secondary combustion zone.

3.4 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons: see 1.4.1 to 1.4.3

4 Dependent Claims 10-24

4.1 Claims 10-24 are dependent on claim 9 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

5 Independent Claim 25

5.1 D3 is regarded as being the prior art closest to the subject-matter of claim 25, and discloses a process for controlling NO_x content in emissions, namely:

A process for controlling NO_x content in emissions from a system (column 4, lines 34-39) wherein a primary fuel is combusted in a primary combustion zone with a primary amount of air, wherein the combustion in the primary combustion zone leaves an air quantity, and a secondary fuel is combusted in a secondary combustion zone with the air quantity from the combustion in the primary combustion zone and leaves an excess air quantity (figure 5; column 5, line 38 to column 6, line 13), the method comprising the steps of:
determining the composition of the primary fuel and secondary fuel (column 7, line 31-50);
determining a flow rate of primary fuel into the system and a flow rate of

secondary fuel into the system (figure 5).

adjusting the flow rate of primary fuel, the flow rate of secondary fuel (figure 5; column 5, line 38 to column 6, line 13).

- 5.2 The subject-matter of claim 25 therefore differs from this known process in that it comprises:
determining an adiabatic flame temperature (AFT) for the composition of the primary fuel and secondary fuel;
determining the excess air quantity required to produce a predetermined NO_x emission level based on the AFT; and
adjusting the flow rate of primary fuel, the flow rate of secondary fuel based on the excess air quantity required to minimize NO_x.
and is therefore new (Article 33(2) PCT).

- 5.3 The problem to be solved by the present invention may be regarded as how to minimize NO_x emissions.

- 5.4 The solution to this problem proposed in claim 25 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

- 5.4.1 It seems rather complicated to arrive at a theoretical temperature level via the adiabatic flame temperature and excess air opposed to simply adjusting the stoichiometric ratios based on different fuel types and their corresponding heating values.

6 **Dependent Claims 26-31**

- 6.1 Claims 26-31 are dependent on claim 25 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

7 **Inventive Step Independent Claim 32**

- 7.1 The present application does not meet the criteria of Article 33(3) PCT, because the subject-matter of claim 32 does not involve an inventive step.
- 7.2 D1 is regarded as being the prior art closest to the subject-matter of claim 32, and discloses a system for controlling NO_x content in emissions from a furnace, namely:

A system for controlling NO_x content in emissions (column 1, lines 5, 6) from a furnace (column 7, line 56), the system comprising:
a burner tile (figure 1, item 91; column 7, line 59) defining a primary combustion chamber (figure 1, item 60 "primary burner section");

a plurality of primary tubes (figures 1, 2: tubes 41) connected to a source of fuel gas (figure 1: fuel input 21 and fuel plenum 24) and a source of combustion air (figure 1: oxidant input 25 and plenum 20; column 1, line 58 "air as oxidant) and which are configured to form an air-fuel mixture (figure 1, mixing tube 41) and are operably associated with the furnace so as to introduce the air-fuel mixture into the primary combustion chamber (figure 1); a plurality of secondary fuel tips (figure 1, item 101; column 8, lines 1-9) connected to the source of fuel gas and operably associated with the furnace such that fuel gas is injected from outside of the burner tile to a point downstream from the primary combustion zone so as to produce a secondary combustion zone (figure 1; column 8, lines 1-9).

- 7.3 The subject-matter of claim 32 therefore differs from this known system in that a computer processing system is operatively connected to the primary injectors and the secondary injectors so as to adjust flow rates through the primary fuel tubes and the secondary fuel tips based on one or more of the composition of the fuel gas, the adiabatic flame temperature of the fuel gas, and measured values for the quantity of NO_x emissions from the furnace, and is therefore new.
- 7.4 The problem to be solved by the present invention may therefore be regarded as how to minimize NO_x emissions.
- 7.5 The solution proposed in claim 32 of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) for the following reasons:
- 7.5.1 Solving the problem, the skilled man would find D3 as it deals - as D1 does - with low NO_x staged combustion and he would readily consider the application of its technical teaching.
- 7.5.2 D3 discloses a burner system (column 1, lines 7, 8) featuring a computer processing system (figure 5, controller 130) operatively connected to the primary injectors and the secondary injectors so as to adjust flow rates through the primary fuel tubes and the secondary fuel tips (figure 5; column 5, line 38 to column 6, line 13).
The control scheme (aiming at favourable stoichiometric ratios) is based on the composition of the fuel gas (column 5, lines 35, 36; column 7, lines 23-29) or measured values for the quantity of NO_x emissions from the furnace (column 7, lines 30-50).

7.5.3 Therefore the skilled man would - solving the problem - provide a controller in order to arrive at favourable stoichiometric ratios in an obvious manner.
The skilled man would - depending on the circumstances - base the control scheme on one of the parameters disclosed in D3, such as the composition of the fuel gas or the measured NOx emissions.

7.5.4 Consequently, the skilled man would arrive at the system claimed in claim 32 without exercising an inventive activity.
Hence, the subject-matter of claim 32 lacks an inventive step over D1 in view of D3.

8 **Dependent Claims 33-39**

- 8.1 Claim 33: the processing steps of
- determine an adiabatic flame temperature for the composition of fuel gas and
 - determine excess combustion-air quantity to produce a predetermined NOx emission level based on the adiabatic flame temperature
- is considered non-obvious, because it seems rather complicated to arrive at a theoretical temperature level via the adiabatic flame temperature and excess air opposed to simply adjust the stoichiometric ratios based on different fuel types and heating values.
- 8.2 Claims 34 to 39 are depending on claim 33 and as such are considered new and inventive.

Re Item VIII

Certain observations on the international application

- 9 The application does not meet the requirements of Article 6 PCT, because claim 9 is not clear.
- 9.1 Line 3 defines that the first end of the plenum is attached to a furnace. This wording leaves the reader in doubt, if the furnace as such is a feature of the claim and therefore establishes a lack of clarity. Similarly, line 12 "extending into **the** furnace" refers back to the feature.
- 10 The application does not meet the requirements of Article 6 PCT, because claim 25 is not clear.

- 10.1 The last three lines claim a variety of alternatives. Yet, only the first three options are linked to the determined **excess air quantity**, which is described as the core of the invention and which is required to achieve the technical effect claimed. This feature is therefore considered as essential for the invention.

The last three lines of claim 25 is therefore understood as:

" adjusting at least one of the flow rate of primary fuel, the flow rate of secondary fuel, the primary amount of air based on the excess air quantity required to minimize NO_x ; and

optionally adjusting the distribution of air within the burner."