

COMPACT BURNER WITH BOTH FUEL AND COMBUSTIVE AIR
REGENERATION

The present invention relates to a compact burner with both fuel and combustive air regeneration.

5 In steel furnaces, high-temperature processes take place, which generally require high-calorific-value fuels for reaching the process temperature, wherein, for example, these temperatures indicatively reach temperatures of up to 1,150°C - 1,320°C in the
10 furnaces.

It should be pointed out, however, that costly energy resources - such as noble chemical sources like natural gas - are specifically used for facilitating variations in the productivity of these apparatuses.

15 It is also known that these large apparatuses consume significant quantities of thermal energy for their functioning. For this reason, attempts are being made in the steel industry to substitute noble energy sources, such as natural gas, with gases produced as
20 by-products generated with other production apparatuses, such as, for example, blast furnaces or coke ovens. This tendency has the benefit of reducing the emission levels of CO₂ on the part of the whole industrial plant. This is the case, as normally the
25 process gases generated as by-products by modern and efficient equipment, generally have increasingly lower

calorific powers. This means that these by-products cannot be easily used as fuels in process equipment operating at high temperatures. These by-products are consequently used with a low efficiency for the
5 generation of electric energy or flare burnt before being released into the atmosphere.

The process equipment is consequently fed with nobler fuels, thus increasing the massive emissions of CO₂ on the part of the whole plant, in addition to
10 increasing the production costs. A more efficient use of the by-products within the production plant therefore allows considerable benefits for the environment and for the profitability of industrial production, to be obtained.

15 All of these issues have resulted in a tendency, particularly in the steel production field, to promote the use of regenerative burners which, by preheating the combustion air, are capable of recovering energy which would otherwise be lost in the exhaust fumes, at
20 the same time allowing the use of by-products characterized by a low calorific value.

In order to allow the use of these by-products having a low calorific value in high-temperature processes, resort is made to preheating the fuel in a
25 centralized heat recovery unit and at times, when available, to mixing with nobler fuels. In order to

optimize the consumption of the noble fuel fraction, resort is also made to regeneration of the combustive air.

Current regenerative burners, however, only preheat
5 the combustive air due to the fact that complex hydrocarbons are subject to cracking phenomena which degrade the effective calorific power released during the combustion process.

In the case of by-products without or with a
10 limited presence of complex hydrocarbons, however, such as, for example blast-furnace gas characterized by a high presence of carbon monoxide, fuel regeneration is advantageous due to:

- 15 - the reduction and potential zeroing of the use of noble fuels;
- the use of more energy-efficiency by-products having a low calorific value;
- the use of said low-calorific products in high-temperature processes;
- 20 - the possibility of feeding the furnace with low calorific gas at room temperature by means of gas pipes having reduced dimensions with respect to preheating the above gas;
- the overall reduction in CO₂ emissions into the
25 atmosphere.

With respect to the known art illustrated in the

prior patent CN204114925U relating to a technology similar in some ways to the present invention, the present invention proposes an improvement in the combustion, to limit the unburned products and allow an
5 easier cold ignition.

US 6036476 A relates to a burner according to the preamble of claim 1 positioned in a combustion apparatus.

WO 2015/075666 relates to a self-regenerating
10 industrial burner and an industrial furnace for effecting combustion processes.

A general objective of the present invention is to provide a regenerative burner capable of regenerating both combustive air and fuel having a low calorific
15 value, such as for example blast-furnace gas, in an extremely simple, economical and function manner for the operating of the production equipment.

A further objective of the present invention is to provide a regenerative burner capable of effecting a
20 stable combustion between fuel and combustive air, both at room temperature, i.e. not regenerated, inside a combustion chamber also initially at room temperature. This mode is important for the starting phase of an industrial furnace, when the fumes inside the chamber
25 are still not sufficiently hot as to guarantee the ignition of the mixture.

Another objective of the present invention is to offer a regenerative burner with the possibility of having a mixed feeding mode as an alternative to that of gas having a low calorific value alone.

5 The structural and functional characteristics of the present invention and its advantages with respect to the known art will appear even more evident from the following description, referring to the enclosed schematic drawings which show an embodiment example of
10 the same invention. In the drawings:

- figure 1 is a raised sectional side view of a compact regenerative burner according to the present invention, and

- figure 2 is a further sectional view of the
15 regenerative burner illustrated in figure 1.

With reference to the figures, a compact regenerative burner according to the present invention is indicated as a whole with 11 and defines a regenerative double-burner.

20 Said regenerative burner comprises as a whole, a refractory block 12, a metallic body 13 of the burner, internally coated with an insulating refractory layer 14, and a pilot burner or an ignition device 15 with flame detection.

25 The space occupied by the ignition device 15 can be used for housing the injection lance of non-regenerated

fuel.

The refractory block 12 is positioned directly facing a combustion chamber of the furnace (not shown).

The metallic body 13 of the burner essentially
5 comprises an air-regeneration unit 16 and a fuel-regeneration unit 17, collaborating and integrated with each other, and supported in the metallic body 13, and both coated by the insulating refractory layer 14. In particular, in the example shown, the air-regeneration
10 unit 16 is provided with a connection flange 18 for the air and regenerated waste fumes. The fuel-regeneration unit 17 is provided with a connection flange 19 for the fuel and regenerated exhaust fumes, for the regeneration and combustion modes, respectively.

15 An inspection and control 20 is positioned on the air-regeneration unit 16, for allowing maintenance operations. Said inspection and control hole 20 comprises a closing flange 21 and a gasket 22 suitable for average temperatures and pressure drops. Another
20 inspection hole 23 is provided on the fuel-regeneration unit 17 for the same reasons, and this also comprises a closing flange 24 with a suitable gasket 25 capable of avoiding harmful and dangerous fuel losses in the surrounding environment.

25 More specifically, the air-regeneration unit 16 comprises a cold plenum 26, a porous regeneration means

27 and a hot plenum 28. The cold plenum 26 allows a uniform distribution of the air entering from the flange 18 when the burner is in combustion mode. The porous regeneration means 27 acts as a heat accumulator
5 during the regeneration mode when the hot exhaust gases are extracted from the combustion chamber of the furnace. This extraction is effected through a duct composed of connected passages comprising a combustion pre-chamber of the burner 29 followed by an
10 intermediate duct 30 towards the hot plenum 28 and the exhaust gases are then cooled by interacting with the cold regeneration means 27.

During the combustion mode, the regeneration means 27 act as heat source for the incoming air which passes
15 through the flange 18, then through the cold plenum 26, through the regeneration means 27 and finally through the intermediate duct 30, in the combustion pre-chamber of the burner 29.

The fuel-regeneration unit 17 operates analogously
20 in both the regeneration mode and also in the combustion mode. For this unit, similar elements are indicated with similar reference numbers as those of the air-regeneration unit 16, followed by an apostrophe. This unit 17 therefore also comprises a
25 cold plenum 26', a porous regeneration means 27' and a hot plenum 28'.

The refractory block 12 of the burner 11 is a hollow block in which the combustion pre-chamber of the burner 29 is positioned. Said combustion pre-chamber of the burner 29 acts as a correct mixer of the reagents
5 in order to establish a stable flame during the cold ignition of the whole double regenerative combustion system which is composed of various double-regenerative burners. This allows only double-regenerative burners to be installed without the need for additional burners
10 for simply pre-heating the combustion chamber of the furnace above the self-ignition temperature, thus offering significant technical and economic advantages with a double-regenerative combustion system. The combustion pre-chamber of the burner 29 also prevents
15 the formation of partial combustion products as the combustion process is correctly started even when cold reagents are used.

The combustion pre-chamber of the burner 29 can be produced in a cavity having different possible forms
20 with various series of passages connected therewith. A first series of adjacent passages comprising intermediate ducts or air inlets 30 and a second series of adjacent passages comprising intermediate ducts or fuel inlets 31 connected by said combustion pre-chamber
25 of the burner 29 towards the air-regeneration unit 16 and towards the fuel-regeneration unit 17,

respectively. According to the present invention, said ducts or adjacent passages 30 and 31 are tilted by an angle α with respect to a horizontal axis x of the burner, wherein said value of α ranges from 0°C to 5 90°C, so as to favour the circulation of both the exhaust gases returning from the combustion chamber of the furnace and also the air and fuel coming from the air-regeneration unit 16 and fuel-regeneration unit 17.

A third series of ducts 32 is positioned between 10 the combustion pre-chamber of the burner 29 towards the combustion chamber of the furnace to allow the passage of the outgoing combustion products when the burner is in combustion mode. When the burner is in regeneration mode, on the other hand, the same passages or ducts 32 15 act differently as passages for the exhaust gases coming from the combustion chamber of the furnace.

In this case, in fact, the combustion pre-chamber of the burner 29 acts as a plenum for said exhaust gases. In this chamber, the fractionation takes place 20 of the flow of exhaust gases coming from the combustion chamber of the furnace into two different flows, i.e. exhaust gases which must be regenerated inside the air-regeneration unit 16 that pass through the passages 30 and exhaust gases which must be regenerated inside the 25 fuel-regeneration unit 17 that pass through the passages 31. The fractionation of the flow-rate of

incoming exhaust gases is effected by means of a correct dimensioning of the passages 30 and 31 which is such as to generate a balanced distribution of the pressure drops. The purpose of this fractionation is to generate, during the regeneration phase, a ratio between the flow-rate of fumes in 30 and that in 31 similar to the ratio between the flow-rate of air in 30 and the flow-rate of fuel in 31 during the combustion phase.

10 The refractory block 12, which characterizes the combustion pre-chamber of the burner 29, is connected to the body of the burner 13 containing the two units, i.e. the air-regeneration unit 16 and the fuel-regeneration unit 17, separated from each other. The combustion pre-chamber of the burner 29 is fed by the hot plenums 28 and 28'.

 The pilot burner 15 with flame detection is positioned in an intermediate area between the air-regeneration unit 16 and the fuel-regeneration unit 17, as it must also be stably connected to the metallic body 13 of the burner.

 It is specifically in this intermediate area of the metallic body 13 of the burner that any possible interaction between the air-regeneration unit 16 and the fuel-regeneration unit 17 must be avoided.

 First of all, the hot plenums 28 and 28' of the two

units 16, 17, in addition to being partially surrounded by the refractory layer 14, are separated by means of an intermediate refractory block 33, for example, but not necessarily, made of prefabricated refractory material. Said intermediate refractory block 33 has the specific function of providing a seal or inherently stable and robust barrier with respect to thermal circulation movements between the air-regeneration unit 16 and the fuel-regeneration unit 17, and also a seal with respect to the refractory block 12.

The special intermediate refractory block 33 surrounds and protects the pilot burner system 15 with flame detection that provides functions of combustion and detection to the flammable mixture inside the combustion pre-chamber of the burner 29. As an alternative to this pilot burner system 15, a spark plug and also a flame detection system can be provided.

The special intermediate refractory block 33 also facilitates and establishes a stable positioning with respect to the associated refractory block 12 by means of specific provisions on their facing connection surfaces in the form, for example, of cuts and ridges. These specific provisions, having various geometrical characteristics, can also be used for increasing the seal between the parts and preventing air leaks from the hot air plenum 28 into the hot fuel plenum 28' or

viceversa, which could possibly lead to the self-ignition of the resulting mixture with consequent danger.

The provision of a metallic body 13 of the burner
5 in a single piece provided with a single front flange 34 for positioning with respect to the furnace, or the combustion chamber of the furnace, simplifies the layout of both the air-regeneration unit 16 and the fuel-regeneration unit 17.

10 The provision of the refractory block 33 intermediately positioned between the air-regeneration unit 16 and the fuel-regeneration unit 17, kept integral by the metallic body 13 of the burner, ensures the isolation of each regeneration unit 16, 17
15 preventing any possible interaction, even accidental, between the same.

Furthermore, in the alternative functioning mode with richer fuel, said refractory block 33 can house, alternatively to the ignition device 15 with flame
20 detection, an injection lance of non-regenerated fuel.

It can therefore be seen how, with respect to the known art of the prior patent CN204114925U, the present invention obtains a marked improvement in the combustion, it limits unburned products and allows an
25 easy cold start: this is due to the introduction of a combustion pre-chamber capable of stabilizing the

combustion, limiting unburned products and allowing the cold ignition of the whole apparatus. Furthermore, the two regenerators of the combustive air and gas, respectively, are integrated in a single compact body, through a design which is able to ensure the safe operation of the burner.

According to the invention, a regenerative burner can also be obtained, with the possibility of a mixed feeding mode alternative to that of low-calorific-value gas alone.

This necessity can arise if the production equipment does not provide the process with the by-products used by the same as fuel, for example during a maintenance stoppage. This, for example, can include the case in which the burner designed for being a double-regenerative burner is fed with a richer fuel, such as liquefied petroleum gas, for example, not injected through the gas regenerator but through another duct.

The forms of the structure for the production of a burner of the invention, as also the materials and assembly modes, can naturally differ from those shown for purely illustrative and non-limiting purposes in the drawings.

The objective mentioned in the preamble of the description has therefore been achieved.

The protection scope of the present invention is defined by the enclosed claims.

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CLAIMS

- 1) A compact burner with both fuel and combustive-air regeneration (11) comprising:
- a refractory block (12), a metallic body (13) of the burner, internally coated with an insulating refractory layer (14), and an ignition device (15) with flame detection,
- wherein said refractory block (12) is positioned directly facing a combustion chamber of a furnace,
- 10 wherein said metallic body (13) of the burner comprises a pair of regeneration units (16, 17) both coated by said insulating refractory layer (14),
- an intermediate refractory block (33) also being provided, which separates said pair of regeneration units (16, 17) and sealingly collaborates with said refractory block (12),
- 15 characterized in that said pair of regeneration units comprises an air-regeneration unit (16) and a fuel-regeneration unit (17) integrated with each other and supported in said metallic body (13),
- 20 said air-regeneration unit (16) and fuel-regeneration unit (17) both being connected to a single combustion pre-chamber of the burner (29) positioned in said refractory block (12), wherein said combustion pre-chamber of the burner (29) is also connected to said ignition device (15) with flame detection interposed in
- 25

said two units (16, 17), wherein said air-regeneration unit (16) and fuel-regeneration unit (17) are connected to said combustion pre-chamber of the burner (29) by means of at least one respective intermediate duct (30, 31) positioned in said refractory block (12).

2) The regenerative burner according to claim 1, characterized in that said air-regeneration unit (16) and fuel-regeneration unit (17) both comprise a cold plenum (26, 26'), a porous regeneration means (27, 27') and a hot plenum (28, 28').

3) The regenerative burner according to claim 1 or 2, characterized in that said air-regeneration unit (16) and fuel-regeneration unit (17) both provide an inspection and control hole (20, 23) provided with a closing flange (21, 24) and a gasket (22, 25).

4) The regenerative burner according to one or more of the previous claims from 1 to 3, characterized in that said air-regeneration unit (16) and said fuel-regeneration unit (17) are connected to said combustion pre-chamber of the burner (29) through a respective first and second series of adjacent passages or ducts (30, 31).

5) The regenerative burner according to claim 4, characterized in that said adjacent passages or ducts (30, 31) are arranged with an inclination of an angle α

with respect to a horizontal axis x of the burner,
wherein said value of α ranges from 0°C to 90°C .

6) The regenerative burner according to one or more of
the previous claims, characterized in that said
5 intermediate refractory block (33) surrounds said
ignition device (15) with flame detection.

7) The regenerative burner according to one or more of
the previous claims, characterized in that said
metallic body (13) of the burner is in a single piece,
10 supports both said air-regeneration unit (16) and said
fuel-regeneration unit (17) and is equipped with a
single front flange (34) for positioning with respect
to the furnace, i.e. the combustion chamber of the
furnace.

15 8) The regenerative burner according to one or more of
the previous claims, characterized in that a housing
space of the ignition device (15) is provided in which
fuel injection is effected.

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Fig. 1

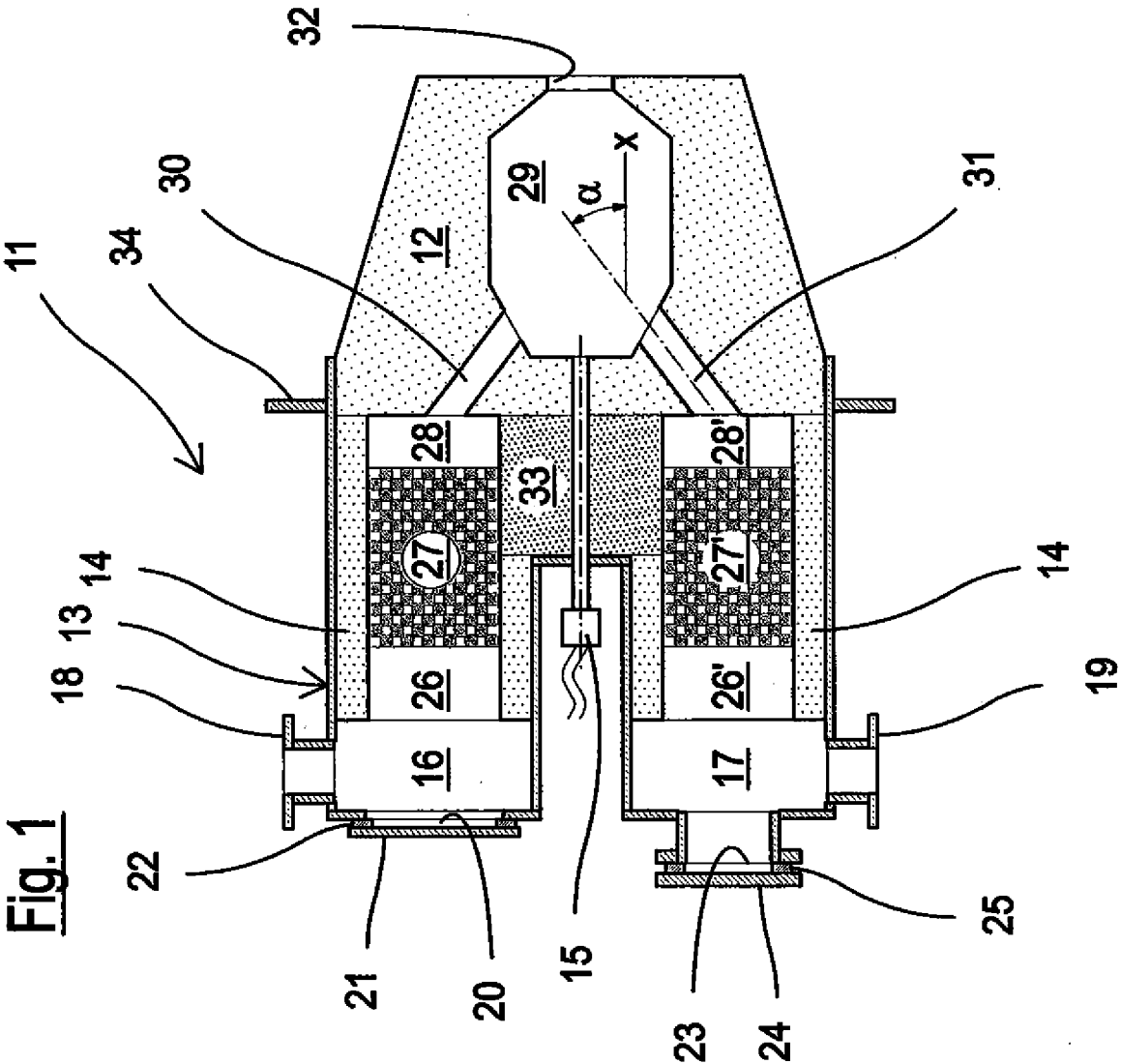
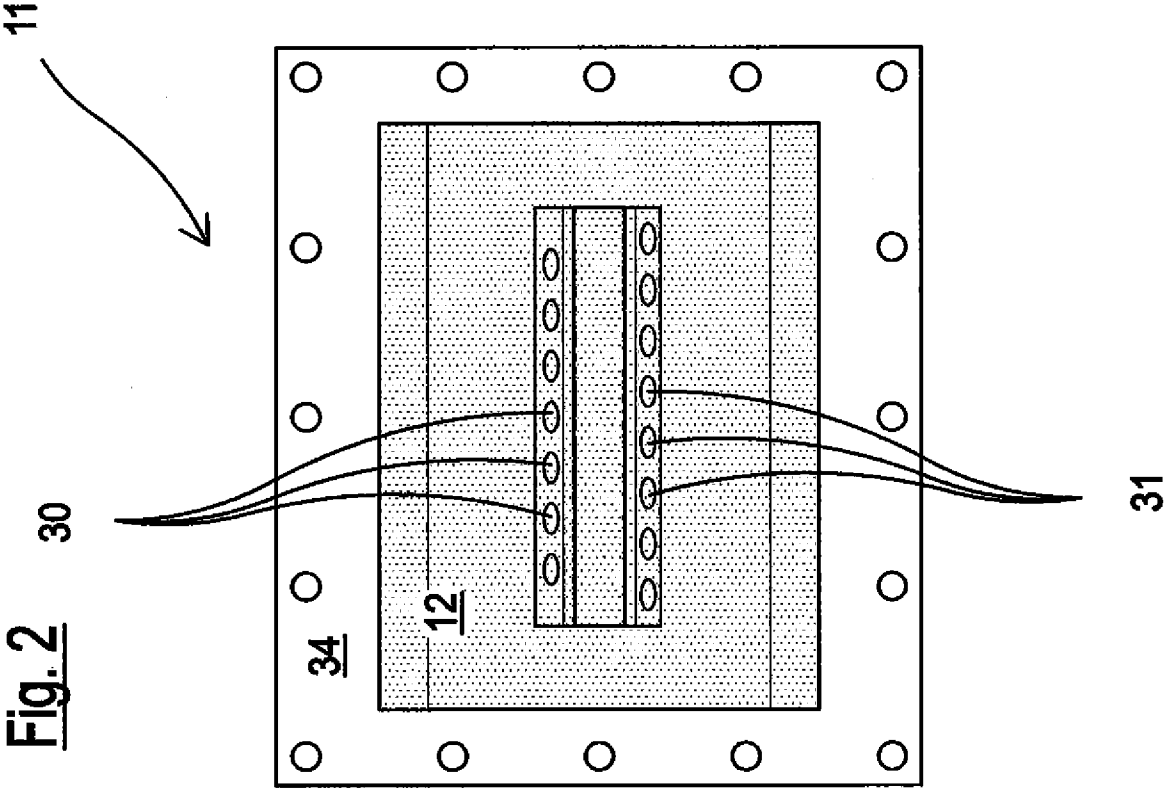


Fig. 2



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/080846

A. CLASSIFICATION OF SUBJECT MATTER

INV. F23L15/02 F23M5/02 F23D14/66
ADD.

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)

F23L F23M F23D F23C

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	JP H07 113509 A (NIPPON FURNACE KOGYO KK) 2 May 1995 (1995-05-02) machine translation; paragraph [0050] figure 12	1-8
A	WO 2015/075666 A1 (TENOVA SPA [IT]) 28 May 2015 (2015-05-28) cited in the application page 23, line 5 - page 25, line 16 figure 6	1,4-6
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Gavriliu, Costin

INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Information on patent family members

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