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Published:

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(54) Title: SEPARATION PROCESSES USING DIVIDED COLUMNS

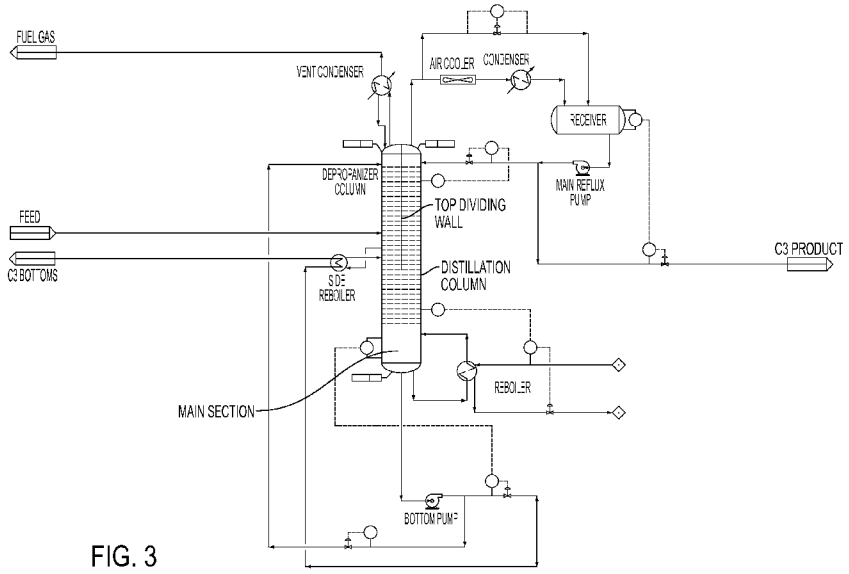

FIG. 3

(57) Abstract: The claimed invention provides a technique wherein the two column system is combined into a single column. The light components are concentrated on the prefractionation side (feed side) of the column, where they are removed as an overhead top product. The middle boiling components are removed as an overhead product on the opposite side of dividing wall. For the same product specifications, top divided column requires substantially lower capital and operating cost than a conventional two-column system.

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Separation Processes Using Divided Columns

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This Application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Ser. No. 61/767,434 filed February 21, 2013, which is incorporated herein by reference in its entirety as if fully set forth herein.

FIELD OF THE INVENTION

[0002] The claimed invention (Top Dividing Wall Column Depropanizer or TDWC) provides an innovative technique wherein the two column system is combined into a single column. The light components are concentrated on the prefractionation side (feed side) of the column, where they are removed as an overhead top product. The middle boiling components are removed as an overhead product on the opposite side of dividing wall. For the same product specifications, TDWC requires substantially lower capital and operating cost than a conventional two-column system.

BACKGROUND OF THE INVENTION

[0003] Distillation and absorption are very common separation techniques used in the process industries. Both techniques require a large amount of energy due to the heating and cooling involved in the process. These techniques were mostly designed more than a decade ago when the economic, political and societal scenarios were different. It would be desirable to reduce the energy cost in the interest of economy as well as society.

[0004] There are complex separation configurations available that offer substantial reduction in energy and capital expenditures. These options include dividing wall columns. Dividing wall columns are normally used in distillation processes. FIG. 1 represents the prior art. The column operates at 390 psig with an overhead temperature of 95°F. This conventional depropanizer aims at separating C_2/C_3 components as an overhead product and C_4/C_{4+} components as the bottoms product of the column.

[0005] However, the prior art possesses several disadvantages. It is not possible to condense the lighter components in the overhead product at 350 psig and using cooling water as the overhead cooling media. The overhead system has a partial condenser. C_2 and lighter components (used as fuel gas) are drawn as the vapor product from the partial condenser. C_3

product is the liquid stream from the partial condenser. A considerable amount of C_3 components are lost to the fuel gas vapor stream. The loss of C_3 components can be prevented by decreasing the overhead temperature (e.g., by using refrigeration) or increasing the column pressure. However, this increases the operating cost of the column. Although the prior art systems offers a sharp split between C_3 and C_{3+}, the recoveries of these components is low as they are lost in the fuel gas vapor stream.

[0006] FIG. 2 represents alternative prior art. This process uses a two column design. The first column is a reboiled absorber which aims at separating non-condensed products from the feed. The non condensables (used as fuel gas) are the overhead vapor product from this column. The bottoms from the first column are fed to the second column. C_3 product is withdrawn as an overhead product in the second column and C_4/ C_{4+} is withdrawn as the bottoms product. Although, this prior art system offers high C_3/C_{3+} recoveries. The disadvantage is higher capital expenditure and higher energy consumption.

[0007] Thus, it would be desirable to have a system that overcomes the disadvantages of the prior art systems.

SUMMARY OF THE INVENTION

[0008] An embodiment of the invention is directed to a process wherein two different unit operations (absorption and distillation) take place on either side of a top dividing wall column. In an embodiment of the invention, the top divided column is used as a depropanizer that recovers C_3 components from fuel gas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 represents a prior art separation process in accordance with an embodiment of the invention;

[00010] FIG. 2 represents a dual column separation process in accordance with an embodiment of the invention; and

[00011] FIG. 3 represents a process scheme in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[00012] An embodiment of the invention is directed to a process wherein two different unit operations (absorption and distillation) take place on either side of a top dividing wall column.

[00013] The innovation is explained through an example, a conventional depropanizing system

[00014] The claimed invention provides an innovative technique wherein a two column system used in a distillation set up is combined into a single column. In certain embodiments of the invention, the light components are concentrated on the prefractionation side (feed side) of the column, where they are removed as an overhead top product. The middle boiling components are removed as an overhead product on the opposite side of dividing wall. Thus, for the same product specifications, the top divided wall column of the claimed invention requires substantially lower capital and operating cost than a conventional two-column system.

[00015] A working representation of the claimed invention is set forth in FIG. 3. A distillation column having a top dividing wall is shown. The top divided column has a feed side that is located on one side of the dividing wall and a product side on the opposite side of the dividing wall. The bottom portion of the top divided column i.e., the opposite side of the top divided column is the main section.

[00016] In an embodiment of the invention, the process scheme of the claimed invention is designed to separate C_2 (Non condensables), C_3 (intermediate component), C_{3+} (Heavies) in a single top divided column. The feed stream is first sent to the pre-fractionation side of the top divided column. The vertical dividing wall splits the top portion of the column into two halves. The feed side of the wall is called the pre-fractionation section. The non-condensables (used as fuel gas) is removed as overhead vapor product from a vent condenser. In certain embodiments of the invention, the column overhead pressure is set at 350 psig via a pressure controller on the overhead fuel gas product line. The section above the feed acts as an absorption section that us primarily used to minimize the loss of C_3 components. The pre-ractionation side has reflux coming from two sources: A liquid stream condensed from a vent condenser; and a heavy stream from a bottoms pump.

[00017] In an embodiment of the invention, the vapor from the overhead of the main section is condensed and cooled to 95°F in air-cooled exchanger followed by the water-cooled condenser. The condenser outlet is collected in an overhead receiver. The C_3 light liquid is pumped out of the drum via reflux pumps. A portion of the light liquid is sent back to the column as reflux and the remainder is withdrawn as C_3 product.

[00018] In an embodiment of the invention, the operating pressure of the column is controlled by a pressure control loop installed on the non-condensable line going to the fuel gas header, while the pressure in the overhead received is controlled by a hot by-pass pressure control loop.

[00019] In an embodiment of the invention, the temperature in top section of the main column is controlled in cascade with the reflux flow control loop. This allows control over the quality of the C_3 product by suppressing the tendency of the heavier components from going to the top of the column.

[00020] In an embodiment of the invention, the reboiler connected to the main section is a thermosyphon steam reboiler that uses steam as heating medium. The heat input to the reboiler is regulated by controlling the steam flow cascaded to the column bottom tray temperature controller.

[00021] The C_3 bottom product is controlled by a level control loop in cascade with the bottom product flow rate.

[00022] Overall aspects of the invention relate to methods for increasing the energy efficiency of a distillation process using a top divided column. Those having skill in the art, with the knowledge gained from the present disclosure, will recognize that various changes could be made to the methods disclosed herein without departing from the scope of the present invention. Mechanisms used to explain theoretical or observed phenomena or results, shall be interpreted as illustrative only and not limiting in any way the scope of the appended claims.

CLAIMS

What is claimed is:

1. A distillation column comprising a wall in a top section of the column having two condensers and a side reboiler

2. The distillation column of claim 1, wherein the two condensers are a partial condenser and a total condenser.

3. The distillation column of claim 1, wherein the column has been used as a depropanizer that recovers C_3 components from fuel gas.

4. The distillation column of claim 1, wherein the column has a feed side or prefractionation side and a main side.

5. The distillation column of claim 4 wherein the feed side acts as a reboiled absorber, which separates non condensables from C_3.

6. The distillation column of claim 4 wherein the prefractionation side contains an absorption solvent.

7. The distillation column of claim 6 wherein a portion of the absorption solvent is sent back to the column as reflux and the remainder is withdrawn as C_3 product.

8. The distillation column of claim 7 wherein the reflux helps in reducing the C_3 loss to the fuel gas.

9. The distillation column of claim 1 wherein the side reboiler is used in the prefractionation side of distillation column.

10. The distillation column of claim 9 wherein the heating medium of the side reboiler is the column bottoms.

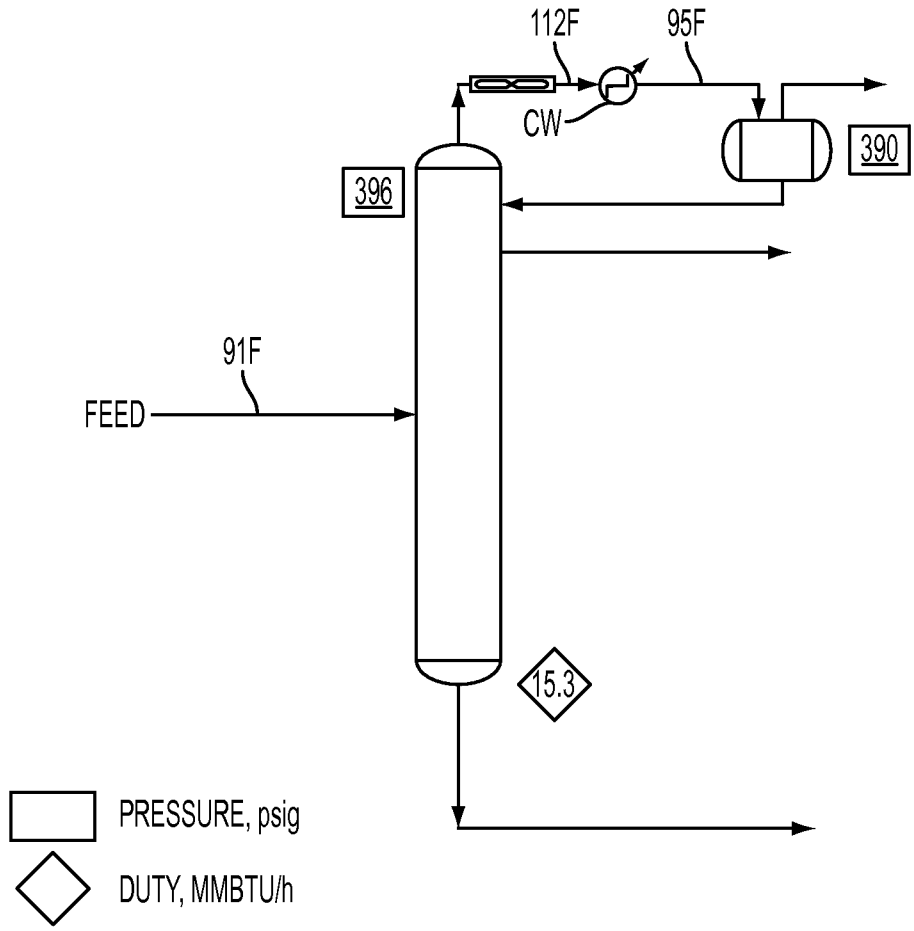

FIG. 1
PRIOR ART

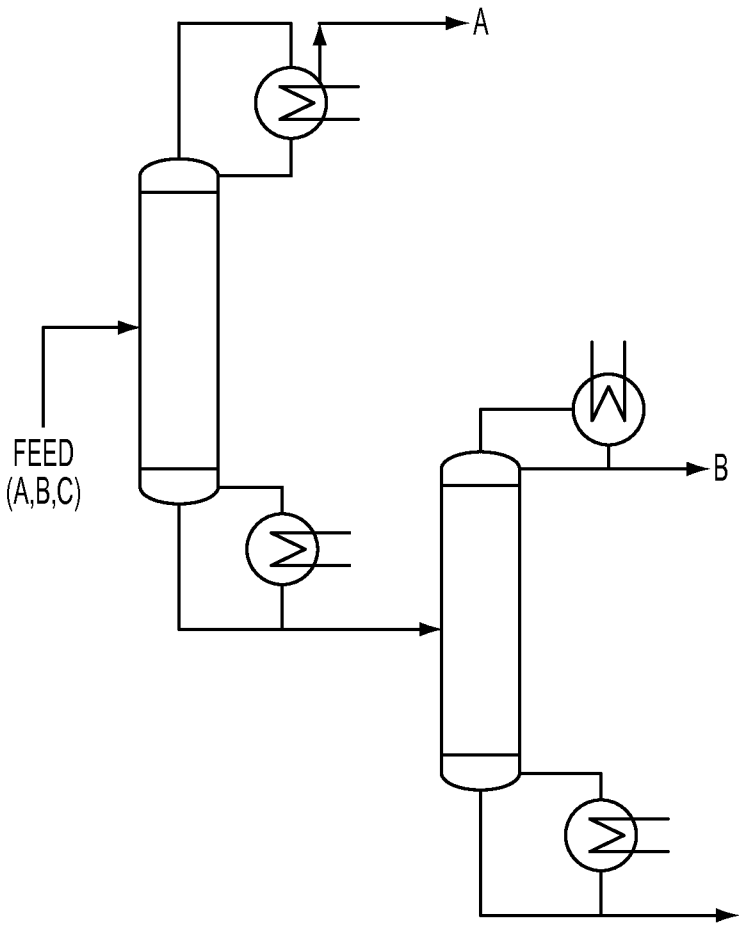

FIG. 2
PRIOR ART

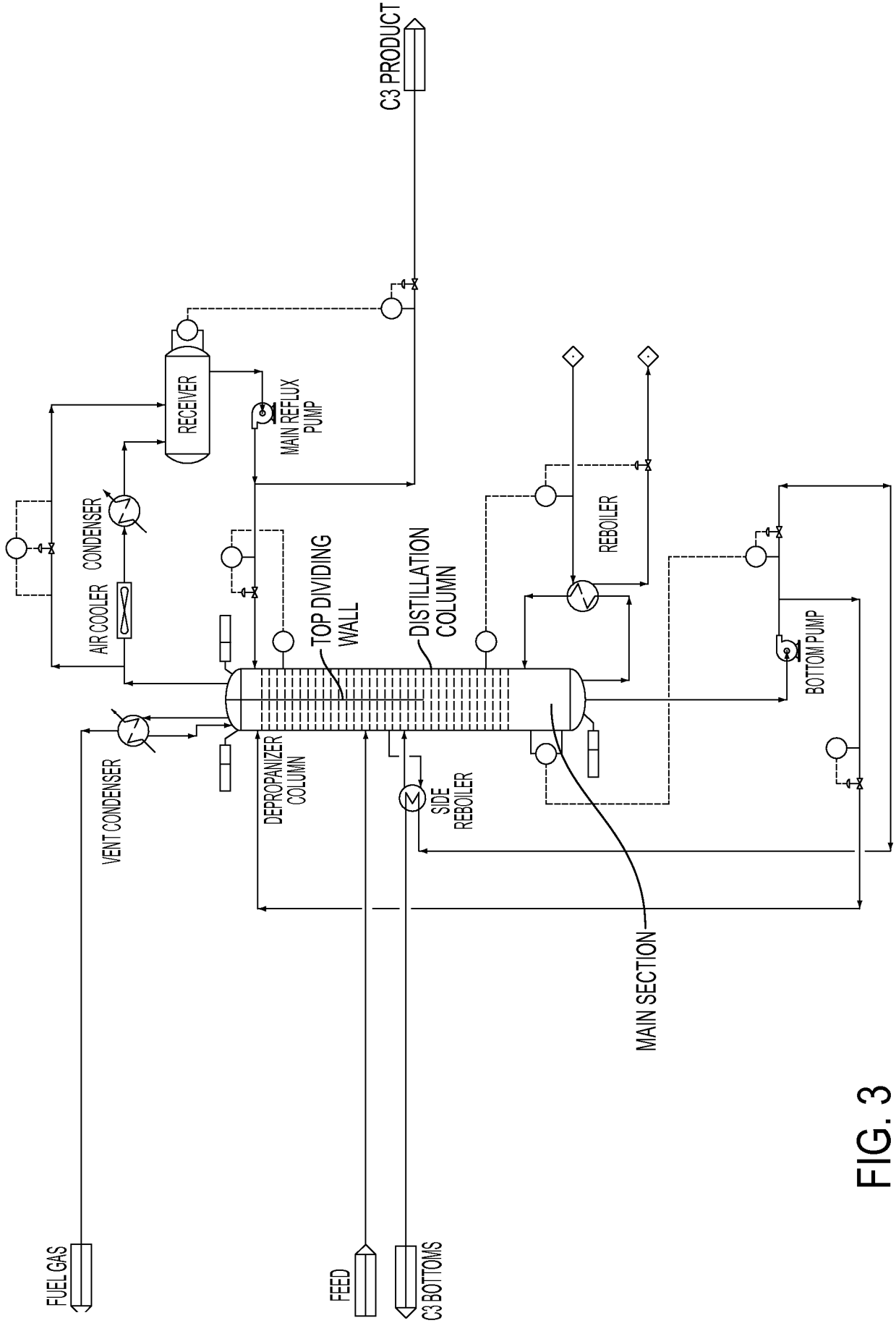
C3 PRODUCT
RECEIVER
MAIN REFLUX PUMP
CONDENSER
AIR COOLER
TOP DIVIDING WALL
DISTILLATION COLUMN
REBOILER
BOTTOM PUMP
VENT CONDENSER
DEPROPANIZER COLUMN
SIDE REBOILER
MAIN SECTION
FUEL GAS
FEED
C3 BOTTOMS

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/31591

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B01D 3/14 (2013.01)
USPC - 203/87
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)
USPC: 203/87
IPC: B01D 3/14 (2013.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - all classes; NPL (keyword limited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; PubWest (PGPB,USPT,USOC,EPAB,JPAB); Dialog Classic (File 315:ChemEng & Biotec Abs, File 35:Dissertation Abs, File 144:Pascal) Google (Scholar)
Search Terms: divided wall, vertical partition, propane, depropanizer, C3, fuel gas

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 8,197,677 B2 (Schultz et al.) 12 June 2012 (12.06.2012); Fig. 1; col 3, ln 8-14; ol 4, ln 15-20; col 3, ln 52-60	1, 2, 4, 9, 10 ---------- 3, 5-8
Y	US 5,709,780 A (Ognisty et al.) 20 January 1998 (20.01.1998); fig 3; col 4, ln 48; col 4, ln 54-59; col 5, ln 5-7; col 5, ln 51-56	5
Y	US 2011/0167868 A1 (Pierce et al.) 14 July 2011 (14.07.2011); fig 1; para [0020]; [0022]; [0024]	3, 8
Y	US 2005/0199482 A1 (Heida) 15 September 2005 (15.09.2005); fig 1; fig 5; para [0002]; [0042]	5-8
A	CN 102190559 A (WU) 21 September 2011 (21.09.2011); fig 1	1-10
A	US 2011/0308930 A1 (Lee et al.) 22 December 2011 (22.12.2011); entire document	1-10
A	US 6,472,578 B1 (Rice) 29 October 2002 (29.10.2002); entire document	1-10
A	US 6,568,208 B1 (Fidkowski et al.) 27 May 2003 (27.05.2003); entire document	1-10

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 May 2013 (02.05.2013)	04 JUN 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)