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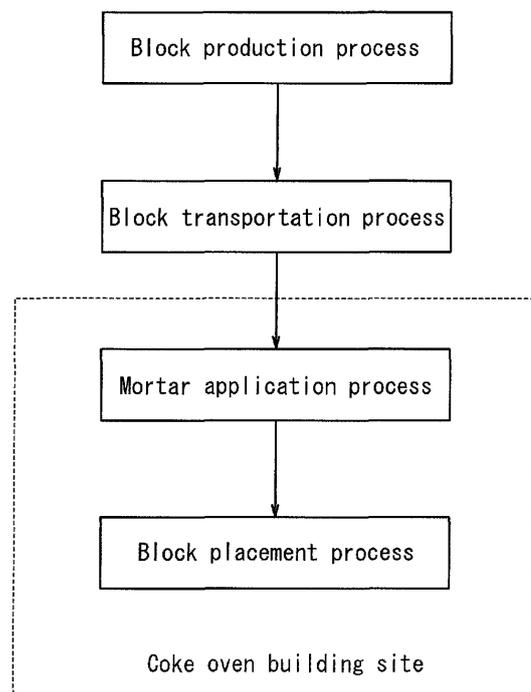
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(54) **METHOD FOR BUILDING COKE OVEN**

(57) Provided is a method for building a coke oven whereby a coke oven can be built efficiently by laying shaped refractories to a high degree of precision while reducing the burden on workers, without using large module bricks. Our method for building a coke oven in order to renew or newly build a coke oven includes producing a block by laying a plurality of shaped refractories at a location other than a building site of the coke oven, transporting the block to the building site of the coke oven, applying mortar to a position for placing the block, and placing the block at the position where the mortar was applied. The length in the longitudinal direction of the block is at least 1/4 and at most 2/3 of an oven length of the coke oven, and the height of the block is less than 2 m.

*FIG. 1*



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## Description

### TECHNICAL FIELD

**[0001]** This disclosure relates to a method for building a coke oven in order to renew or newly build an entire coke oven. In particular, this disclosure relates to a method for building a coke oven whereby a coke oven can be built efficiently by laying shaped refractories precisely while reducing the burden on workers, without the use of large module bricks.

### BACKGROUND

**[0002]** Metallurgical coke used to manufacture steel is produced in a chamber-type coke oven by destructive distillation of coal. A chamber-type coke oven is structured by arranging carbonization chambers and combustion chambers that supply heat to the carbonization chambers alternately in the oven width direction. Heat is supplied from the combustion chambers to the carbonization chambers through refractories, such as refractory bricks, that separate the carbonization chambers and the combustion chambers. Some chamber-type coke ovens have 100 or more oven chambers. These gigantic brick structures reach a total length of 100 m or more and a height of 10 m or more.

**[0003]** The refractories that constitute the coke oven are gradually damaged due to exposure to high temperatures exceeding 1000 °C and to friction produced when coke that is obtained by destructive distillation of coal is extruded horizontally and removed. Therefore, coke ovens are used while performing simple repair with a method such as thermal spraying, or partial re-laying repair primarily on the oven port. A typical lifetime, however, is considered to be 40 to 50 years, and deteriorated coke ovens need to be renewed or newly built.

**[0004]** Coke ovens are typically built by having oven construction workers manually lay shaped refractories, such as bricks. Specifically, this operation is typically performed as follows.

**[0005]** A coke oven has a complicated structure. The contact surface between vertically-laid shaped refractories is horizontal and is designed to be aligned at the same height throughout. Layers are counted in the order of the first layer, the second layer, etc. from the bottom. During new building of a coke oven or building to renew a shaped refractory structure, a total of several hundred oven construction workers are deployed in groups of several dozen to fixed areas, and the workers lay one or two layers per day of shaped refractories in order from the bottom of the oven.

**[0006]** Each of the shaped refractories is laid during this operation as follows. First, the shaped refractories to be used are carried into the working height in advance using a crane or the like and are arranged near the position of construction. Mortar is produced using a mixer, placed in a container, and carried into the worksite by a

crane or the like. The mortar is then divided into small portions and arranged near the position of construction. At the position where the shaped refractories are to be laid, the oven construction workers then apply mortar using a trowel to yield a predetermined joint thickness (method where mortar is applied to the laid refractories). Next, the workers take a shaped refractory that was placed nearby and lay it on top of the mortar, without trapping air therebetween. After adjusting the position of the laid shaped refractory using a level gauge or the like, the next shaped refractory is displaced horizontally to the laying position. By repeating the above procedure, one layer of shaped refractories is laid. Once laying of one layer of shaped refractories is complete, it is confirmed whether the required precision has been achieved. Any problematic spots are re-laid, and then the laying operation for the next layer begins.

**[0007]** The above-described type of oven building by manual laying, however, has the following problems. First, the shaped refractories that are used in the coke oven weigh approximately 5 kg to 10 kg each. Both arranging these shaped refractories in advance at the worksite and actually laying them require heavy physical labor, placing a significant burden on the workers.

**[0008]** Also, the coke oven needs to be built with a complicated combination of shaped refractories that come in a variety of shapes, such as a rectangle, trapezoid, L-shape, or the like as seen from above, unlike typical construction bricks. In addition, the shaped refractory structure of the coke oven needs to have an extremely high degree of precision. For example, the walls of the combustion chambers are required to be highly smooth, with an unevenness of 1 mm or less. Refractory bricks that are typically used as shaped refractories for coke ovens, however, are produced by firing. As a result, the error in the dimensions of each refractory brick is approximately 1 mm to 2 mm. Therefore, the required precision cannot be obtained by simply laying refractory bricks. After taking into account the variation in brick dimensions, bricks with complicated shapes need to be laid while making manual adjustments so as to achieve the final dimensional accuracy of the coke oven. Accordingly, an extremely high level of skill is required to lay the shaped refractories of a coke oven, but there is always a shortage of such experienced oven construction workers.

**[0009]** For these reasons, there is a demand for the development of a method that allows shaped refractories to be laid efficiently with little manual labor.

**[0010]** For example, JP H04-213388 A (PTL 1) proposes a technique for using integrally formed large module bricks to repair a re-laid portion of a heating chamber in a coke oven. The module bricks are prepared in advance by pouring a slurry for refractories into a mold and firing. The flue forming the combustion chamber of the coke oven and the walls of the carbonization chamber are formed integrally. This technique uses module bricks with larger dimensions than the refractory bricks used in regular manual laying. The time for repair work in the

coke oven can therefore be shortened, reducing the workload.

**[0011]** JP 2011-503254 A (PTL 2) proposes a technique for attaching an outer mold and a consumable inner mold (core) to a location where the refractory brick wall of the coke oven needs to be repaired, pouring a refractory castable material into the molds, and then hardening by firing. In this technique, repair does not need to be made by laying shaped refractories, thereby reducing the workload.

## CITATION LIST

### Patent Literature

#### **[0012]**

PTL 1 : JP H04-213388 A

PTL 2: JP 2011-503254 A

## SUMMARY

### (Technical Problem)

**[0013]** In the technique in PTL 1, however, large modules that are produced by firing a slurry are used. Therefore, strain may be generated when the module is heated, leading to cracks. Also, if a crack forms for example when the module is transported to the building site, the crack grows long in accordance with the size of the module.

**[0014]** In the technique in PTL 2 as well, a larger portion than a regular-sized shaped refractory is molded integrally and fired. Therefore, cracks tend to occur upon the application of heat. Furthermore, the accuracy of the resulting repaired section depends on the accuracy of the mold. However, the mold has a complicated shape, and at the repair site, it is difficult to install the outer mold and the consumable inner mold accurately.

**[0015]** Additionally, the techniques in PTL 1 and PTL 2 are both for partially repairing a coke oven. No consideration is made of application to renewing or newly building an entire coke oven. Since repairs are typically partial and the work is hot, the speed of work is given greater importance than the accuracy of work for repairs. By contrast, a much higher degree of accuracy than for repair is required when newly building an oven, since operation of the oven over an extended period of time is assumed.

**[0016]** Therefore, it would be helpful to provide a method for building a coke oven in order to renew or newly build an entire coke oven whereby a coke oven can be built efficiently by laying shaped refractories precisely while reducing the burden on workers, without the use of large module bricks.

### (Solution to Problem)

**[0017]** The primary features of our method are as follows.

1. A method for building a coke oven in order to renew or newly build a coke oven, the method comprising:

producing a block by laying a plurality of shaped refractories at a location other than a building site of the coke oven;  
transporting the block to the building site of the coke oven;  
applying mortar to a position for placing the block; and  
placing the block at the position where the mortar was applied;  
wherein a length in a longitudinal direction of the block is at least 1/4 and at most 2/3 of an oven length of the coke oven, and a height of the block is less than 2 m.

2. The method for building a coke oven of 1., wherein at least one of the blocks is for forming a regenerator of the coke oven.

3. The method for building a coke oven of 1. or 2., wherein at least one of the blocks is for forming a combustion chamber of the coke oven.

4. The method for building a coke oven of any one of 1. to 3., further comprising manually laying shaped refractories at the building site of the coke oven.

5. The method for building a coke oven of any one of 1. to 4., wherein during the producing, the block is produced using a robot.

6. The method for building a coke oven of any one of 1. to 5., wherein during the producing, the block is produced using a robot with an arm for laying shaped refractories and a robot with an arm for applying mortar.

### (Advantageous Effect)

**[0018]** According to our method for building a coke oven, an entire coke oven can be renewed or newly built by laying shaped refractories precisely while reducing the burden on workers, without the use of large module refractories.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]** In the accompanying drawings:

FIG. 1 is a flowchart schematically illustrating a method for building a coke oven in one of the embodiments of this disclosure.

## DETAILED DESCRIPTION

**[0020]** A detailed description of our method is given below. The following is merely one embodiment of our method, and this disclosure is in no way limited to the method described below. In the following explanation, unless noted otherwise, the terms up, down, horizontal,

vertical, and height are used to refer to shaped refractories, and to blocks manufactured by laying the shaped refractories, taking the orientation upon incorporation into the coke oven as a reference.

**[0021]** FIG. 1 is a flowchart schematically illustrating a method for building a coke oven in one of the embodiments of this disclosure. Our method for building a coke oven is for renewing or newly building a coke oven. As illustrated in FIG. 1, our method includes at least processes (1) to (4). Whereas (3) and (4) are performed at the coke oven building site, process (1) is performed at a location other than the coke oven building site.

- (1) A block production process for producing a block by laying a plurality of shaped refractories at a location other than a coke oven building site;
- (2) a transportation process for transporting the block to the coke oven building site;
- (3) a mortar application process for applying mortar to a position for placing the block; and
- (4) a block placement process for placing the block at the position where the mortar was applied.

**[0022]** In this disclosure, "renewing or newly building a coke oven" includes the cases of dismantling the shaped refractory structure of an existing coke oven and newly building a shaped refractory structure on the existing foundation after removal (pad-up), building a coke oven completely new, adding on an oven section adjacent to an existing coke oven, and the like.

**[0023]** The aforementioned processes (1) to (4) will be described in detail below.

**[0024]** [Block production process]

**[0025]** In the block production step, blocks are produced by laying a plurality of shaped refractories at a location other than a coke oven building site. At the coke oven building site, a coke oven can be built by placing the blocks. This approach reduces the conventional labor by oven construction workers to manually place shaped refractories one by one at a building site with poor operability, thereby significantly improving the work efficiency at the building site.

**[0026]** The aforementioned "location other than a coke oven building site" may be any location that differs from the coke oven building site and that allows production of a block by laying shaped refractories. For example, the block production process may be performed at a location adjacent to the coke oven building site, such as land adjacent to a temporary shed provided at the location for building the coke oven. If the coke oven is being built within the steelworks, the block production process may be performed at another location within the steelworks. The blocks may also be produced at a location distant from the coke oven building site. Considering the time and cost for transportation, however, the blocks are preferably produced at a location adjacent to the coke oven building site. To improve efficiency, the block production step is preferably performed intensively at one location.

Blocks produced at a plurality of locations, however, may be transported and carried into one coke oven building site.

**[0027]** The blocks may be for forming any portion of the coke oven, but forming blocks from portions that have a relatively simple structure or portions that are repeatedly produced greatly increases work efficiency. Therefore, at least one of the blocks is preferably for forming either a regenerator or a combustion chamber. No upper limit is placed on the number of blocks that form the regenerators or the combustion chambers, and all (100%) of the blocks that are used may form the regenerators or the combustion chambers.

15 [[Shaped refractories]]

**[0028]** No restriction is placed on the shaped refractories for producing the blocks. Any shaped refractories may be used, such as bricks, precast blocks, and the like. Among these, typical shaped refractories used when building a coke oven by manual laying are preferably used. By using typical shaped refractories, a similar oven to conventional ovens can be designed even when building an oven with our method. As a result, performance that is at least equivalent to that of a conventional oven can be guaranteed. Also, if a crack forms when using large module bricks, the crack might spread across the entire module. By using typical shaped refractories, however, even if a crack forms in one shaped refractory, propagation of the crack can be stopped within that shaped refractory. Typical shaped refractories refer to all shaped refractories that are for manual laying and are not module bricks. The measurements thereof are generally a height of 10 cm to 15 cm and a horizontal length of 20 cm to 40 cm.

30 [[Production of blocks by manual laying]]

**[0029]** The aforementioned blocks can be produced by manual laying. In this case, unlike the case of manually laying shaped refractories at the coke oven building site, a sufficient workspace can be ensured. Hence, the burden on workers can be reduced, even for the same manual laying. Furthermore, in the case of laying shaped refractories at the coke oven building site, work needs to be performed after assembling scaffolding to match the height of the laid shaped refractories. In this disclosure, however, the operation to lay shaped refractories is performed at a location other than the coke oven building site. Therefore, there is no need to use scaffolding or the like, and work can be performed on steady ground.

45 [[Production of blocks by a robot]]

**[0030]** The aforementioned blocks may also be produced using a robot. In this case, a portion or all of the block production process can be automated, thereby reducing the number of workers involved in heavy physical

labor, such as manually laying shaped refractories. Also, the use of robots allows automatization of the operation to lay shaped refractories, which requires a high level of skill.

**[0031]** Any type of robot may be used to produce blocks. A robot with a movable arm capable of handling shaped refractories or the like is preferably used. An example of the aforementioned robot with an arm is a vertically articulated robot that is a type of industrial robot. Blocks may also be produced using a robot with an arm for laying shaped refractories and a robot with an arm for applying mortar.

[[Block production line]]

**[0032]** There may be one or a plurality of block production lines, regardless of whether blocks are produced by manual laying or using robots. By producing blocks with multiple lines, the supply rate of blocks to the coke oven building site can be increased. Therefore, in terms of work efficiency, the number of block production lines is preferably at least two and more preferably at least three. No upper limit is placed on the number of production lines, but if more lines than necessary are provided, then the rate determining processes become the subsequent block transportation process and the processes that are performed at the coke oven building site, i.e. the mortar application process and block placement process. It thus becomes difficult to increase the speed of coke oven building any further, reducing the cost effectiveness of additional production lines. Accordingly, the number of lines is preferably determined in light of factors such as the scale of the coke oven and the operation speed in each process.

[[Block size]]

**[0033]** In this disclosure, it is important that the length in the longitudinal direction of the block produced in the block production process be at least 1/4 and at most 2/3 of the oven length of the coke oven to be built, and it is important that the height of the block be less than 2 m. When the block is produced by manual laying, shaped refractories are laid at a high position if the block is excessively high. Therefore, a working floor needs to be provided by some method, such as by assembling scaffolding. For example, in Japan, Article 518 of the Ordinance on Industrial Safety and Hygiene stipulates that a working floor needs to be provided if there is a danger of a fall when performing work at a height of 2 m or greater. If the height of the block is less than 2 m, there is no need to install scaffolding or the like and carry out work in high places, even when producing the block by manually laying shaped refractories. Hence, the work efficiency is high. Also, in the case of producing blocks using robots, if the height of the block is less than 2 m, then the position where shaped refractories are laid is within the range of arm mobility of a typical robot with an arm. Therefore, a

block can be produced by simply moving a robot horizontally, thus yielding high work efficiency. No particular lower limit is placed on the height of the block, but the block preferably contains at least two layers of shaped refractories. Setting the length in the longitudinal direction of the block anywhere from at least 1/4 to at most 2/3 of the oven length of the coke oven to be built is acceptable. In terms of workability in the below-described block transportation process, however, the length in the longitudinal direction of the block is more preferably at least 1/4 to at most 1/2 of the oven length of the coke oven.

**[0034]** As referred to here, the "length in the longitudinal direction of the block" indicates the length in the longitudinal direction in a horizontal cross-section of the block. The "height of the block" indicates the height from the lower surface to the upper surface of the block. Any unevenness, such as dowels provided on the sides, the upper surface, and the bottom surface of the block, is not included in the aforementioned "length in the longitudinal direction of the block" and "height of the block". The "oven length of the coke oven" refers to the length in the longitudinal direction of the combustion chambers and carbonization chambers constituting the coke oven. The typical oven length of coke ovens currently in use is approximately 15 m to 17 m.

[Block transportation process]

**[0035]** Blocks produced by the aforementioned block production process are transported to the coke oven building site after completion of drying. Any method may be used for transporting blocks in the block transportation process. In accordance with factors such as the distance between the block production site and the coke oven building site, one or a combination of a plurality of methods may be used, such as a truck, a transporter (a self-propelled transport carriage), a crane, or the like. In this disclosure, the block is relatively small, since the length in the longitudinal direction of the block is at least 1/4 and at most 2/3 of the oven length of the coke oven, and the height of the block is less than 2 m. Therefore, a typical transportation method and means may be used, thereby reducing costs. For example, when a temporary shed is provided at the coke oven building site, the block may be transported from the block production site to the temporary shed by a transporter. Within the temporary shed, the block may be transported to the position of construction using a combination of a ceiling crane and a stage jack. In the block transportation process, the block can also be transported directly from the block production site to the position of construction at the coke oven building site. Alternatively, the block may first be transported to a block storage site and stored temporarily. In accordance with progress on oven building, the block may then be transported from the block storage site to the position of construction at the coke oven building site.

[Mortar application process]

**[0036]** Next, mortar is applied to a position for placing a block. Any method for applying mortar may be used. As in the case of laying shaped refractories, it suffices to apply mortar to the positions contacted by the bottom and sides of the block. In other words, it suffices to apply mortar to the upper surface and the sides of the position where the block is placed.

**[0037]** Among the surfaces where mortar is applied, a spacer may be placed on the portion that contacts the bottom of the block being installed, i.e. the portion that becomes the horizontal joint. At this portion, it might not be possible to ensure the desired joint thickness due to pressure from the load of the block. By providing a spacer and installing the block on top of the spacer, the joint thickness can easily be ensured. A spacer having the same height as the joint thickness is preferably used.

[Block placement process]

**[0038]** Next, a block is placed at the position where the mortar was applied in the mortar application process. Any method for placing the block may be used. For example, the block may be lifted by a crane or the like, and while adjusting the position of the block, the block may be placed on the surface where the mortar was applied. In this way, by building in units of blocks, the burden on workers is reduced as compared to when manually laying shaped refractories one by one. Hence, shaped refractories can be laid to a high degree of accuracy.

[Process to manually lay shaped refractories]

**[0039]** In our method for building a coke oven, a coke oven can be built by repeatedly performing the above processes. At this time, the aforementioned blocks can be used to build the entire coke oven, or a portion of the coke oven may be built using blocks, with the remaining portion being built by manual laying. In particular, forming blocks from portions that have a relatively simple structure or portions that are repeatedly produced greatly increases work efficiency. Therefore, either or both of the regenerators and the combustion chambers are preferably built using blocks, and other portions such as a corbel with a complicated structure are preferably built by manual laying.

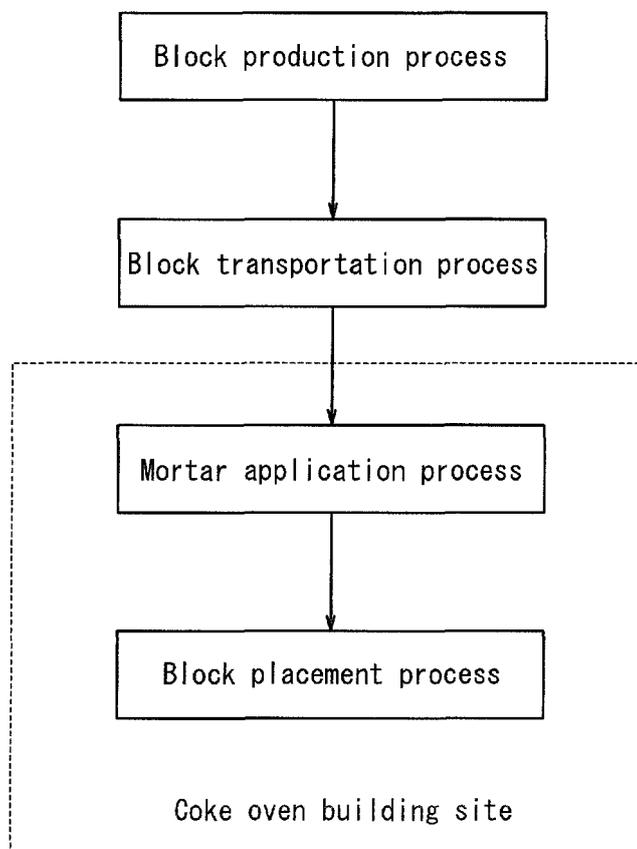
INDUSTRIAL APPLICABILITY

**[0040]** According to our method for building a coke oven, a coke oven can be built efficiently by laying shaped refractories to a high degree of precision while reducing the burden on workers, without using large module bricks. Therefore, our method is extremely effective for renewing or newly building an entire coke oven.

Claims

1. A method for building a coke oven in order to renew or newly build a coke oven, the method comprising:
  - 5 producing a block by laying a plurality of shaped refractories at a location other than a building site of the coke oven;
  - 10 transporting the block to the building site of the coke oven;
  - 15 applying mortar to a position for placing the block; and
  - 20 placing the block at the position where the mortar was applied;
  - 25 wherein a length in a longitudinal direction of the block is at least 1/4 and at most 2/3 of an oven length of the coke oven, and a height of the block is less than 2 m.
2. The method for building a coke oven of claim 1, wherein at least one of the blocks is for forming a regenerator of the coke oven.
3. The method for building a coke oven of claim 1 or 2, wherein at least one of the blocks is for forming a combustion chamber of the coke oven.
4. The method for building a coke oven of any one of claims 1 to 3, further comprising manually laying shaped refractories at the building site of the coke oven.
5. The method for building a coke oven of any one of claims 1 to 4, wherein during the producing, the block is produced using a robot.
6. The method for building a coke oven of any one of claims 1 to 5, wherein during the producing, the block is produced using a robot with an arm for laying shaped refractories and a robot with an arm for applying mortar.

*FIG. 1*



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/001762

## A. CLASSIFICATION OF SUBJECT MATTER

C10B29/02(2006.01)i, F27D1/00(2006.01)i, F27D1/16(2006.01)i

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)

C10B29/02, F27D1/00, F27D1/16

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	JP 2010-520321 A (Saturn Machine & Welding Co., Inc.), 10 June 2010 (10.06.2010), & US 2008/0210539 A1 & WO 2008/108891 A1 & CA 2679671 A	1-6

 Further documents are listed in the continuation of Box C. See patent family annex.

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09 May 2016 (09.05.16)

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Name and mailing address of the ISA/  
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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/001762

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Form PCT/ISA/210 (continuation of second sheet) (January 2015)

**REFERENCES CITED IN THE DESCRIPTION**

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