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(54) **Tap hole measuring device for a bof vessel and method for measuring the thickness of a refractory lining in a tap hole of a bof vessel**

(57) The invention describes a tap hole measuring device for a BOF vessel used in steel production, the BOF vessel (1), comprising an internal refractory lining (3) and a tap hole (2), which includes an opening (5) and a flange (4) with a planar surface. The measuring device comprises a movable monitoring car (7), a steel rod (8) with a fan-shaped metal washer (9) mounted on one end of the rod (8), the other end of the rod (8) being fixed in

a releasable manner in a tubular coupling sleeve (10) of the movable monitoring car (7) and a laser measuring device (11) placed in the vicinity and aligned parallel to the rod (8) on the movable monitoring car (7). The present invention is also related to a method for measuring the thickness of a refractory lining in a tap hole (2) of a BOF vessel (1) using the tap hole measuring device.

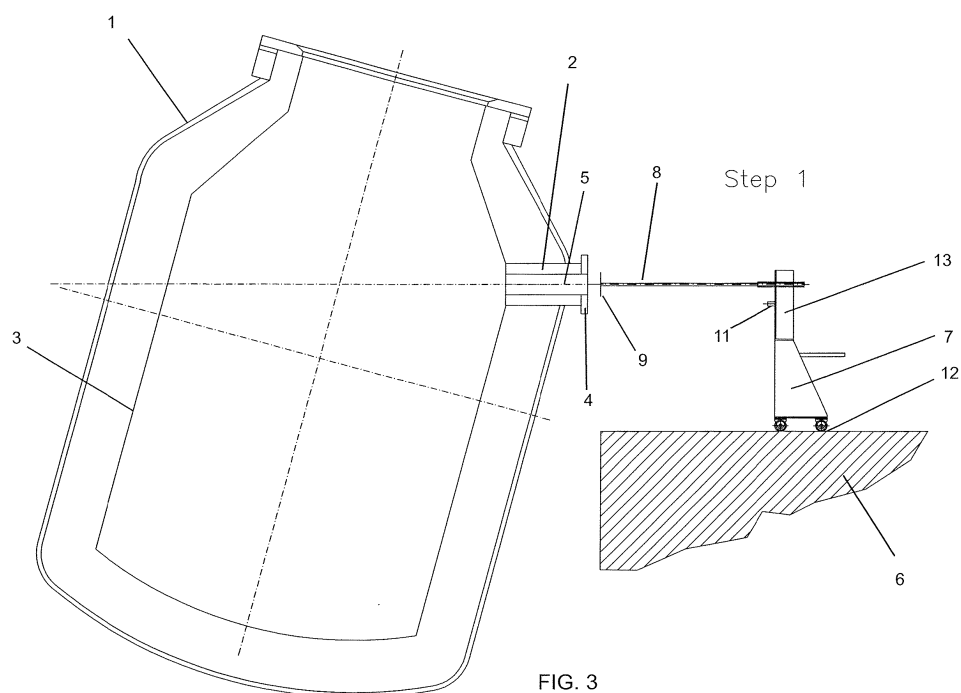


FIG. 3

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Description

[0001] The present invention is related to a tap hole measuring device for a BOF vessel used in steel production, the BOF vessel, comprising an internal refractory lining and a tap hole, which includes an opening and a flange with a planar surface. The present invention is also related to a method for measuring the thickness of a refractory lining in a tap hole of a BOF vessel using the tap hole measuring device.

Description of the state of the art

[0002] A Basic Oxygen Furnace (BOF) is a steel making furnace which converts hot metal and steel scrap into steel by the oxidizing action of oxygen, which is blown through a lance into the metal melt above the slag line. Almost 70 % of all steel in the world is produced on BOFs.

[0003] The refractory lining of BOFs work under severe conditions, i.e. very high temperatures and an oxidizing atmosphere. Especially in the slag line there is a fast wearing of the lining. Refractory bricks for lining BOFs are made either of resin bonded magnesite or tar bonded mixtures of magnesite (MgO) and burnt lime (CaO). A properly maintained lining may serve up to 20.000 heats.

[0004] The regular inspection of the lining of a BOF is therefore essential for its successful operation. There are several technologies presently in use to control the thickness of the lining inside a BOF. One example is the laser measurement technology using a non-contact measurement of the lining in metallurgical vessels via a pulsed laser beam which is deflected by a rotating mirror system. One example of this technology is known commercially as LaCam from Minteq Ferrotron. Another example of laser measuring technology is laser contouring technology (LCS) provided by Process Metrix. Using these technologies a three dimensional frame of the vessel's inner surface is created in a very short time. These technologies, however, require a scanning unit with a pulsed semiconductor diode laser with electro-optical range measurement and a two axis scanning mechanism. The measurement must be performed in different angular directions. The range data together with the associated angles enables a 3D image of the vessel. As can be seen, this is a very sophisticated and expensive system. Even the use of mobile units incorporating the mentioned technology requires a high investment and trained personnel.

[0005] A simpler and not so cost intensive method of measuring the lining at the tap hole is necessary. The tap hole, which is used to pour the steel to a ladle at the end of production cycle, is positioned usually on the side of the BOF in the transition zone between the cylindrical shell and the upper cone. Since the BOF is capable of rotating around its horizontal axis on trunnions driven by electric motors, the tap hole can be easily positioned on the level of a platform from which an operator may execute a measurement of its length.

[0006] One existing method is to insert a metal ruler

with a bended end inside the tap hole and read its length. The bended end must engage against the lining surface inside the vessel. The measurement of the length is performed on regular intervals after a determined number of heats. The progressive wear of the lining in the tap hole region inside the vessel can so be registered.

[0007] This simple solution has the problem of lack of precision and requires a skilled operator to correctly engage the bended end of the ruler against lining wall, furthermore it must be performed quickly due to the heat coming out of the tap hole, which also may deform the ruler.

[0008] The present invention presents a technology which allows a precise and quick measurement of the lining thickness in the region of the tap hole in a BOF. The device of the present invention has a relative low cost and does not require a skilled operator for its proper handling.

Brief description of the invention

[0009] The present invention describes a device and a method for measuring the lining thickness in the tap hole region of a BOF.

[0010] The device comprises a movable monitoring car with a support structure and a laser measuring device. The movable monitoring car can be properly protected against the heat coming from the BOF, especially from the open tap hole. It also includes a rod, with a predetermined length, with one end to be inserted in a tubular coupling sleeve in the support structure and a fan shaped washer to be mounted on the other end of the rod. The tubular coupling sleeve of the support structure is adjustable in height to allow the insertion of the rod with the fan-shaped washer inside the tap hole in aligned conditions. The rod is inserted with its longitudinal axis aligned with the longitudinal axis of the tap hole.

[0011] The method of measurement includes the step of positioning the tap hole of a BOF at the level of a platform. The movable monitoring car is transported at the platform close to the tap hole with the rod inserted in the tubular coupling sleeve of the support structure and the fan-shaped washer mounted at the opposed end of the rod. The fan-shaped washer has an outer diameter that is greater than the diameter of the tap hole opening, with the effect that the rod with the fan-shaped washer is inserted with interference inside the tap hole causing thereby a resistance against its movement through the tap hole. When this resistance against the insertion movement ends the fan-shaped washer is already inside the BOF vessel. The movable monitoring car is thereafter pulled back until a resistance is felt again, the said resistance resulting from the fan-shaped washer facing the internal lining wall of the BOF. At this point the movable monitoring car is stopped and the laser measuring device is used to determine the distance between the movable monitoring car and the surface of the flange of the tap hole. Since the distance between the surface of the flange

and the internal face of the steel wall of the BOF is known from its project, it is possible to determine the remaining thickness of the refractory lining inside the BOF in the region of the tap hole.

Brief description of the figures

[0012] The present invention will be described in detail based on one embodiment shown in the drawings. The figures showing:

- Figure 1- is a side view of the tap hole measuring device of the present invention;
- Figure 2 - is a front view of the tap hole measuring device of the present invention;
- Figure 3 - is the first step of the tap hole measuring method according to the present invention;
- Figure 4 - is the second step of the tap hole measuring method according to the present invention;
- Figure 5 - is the third step of the tap hole measuring method according to the present invention; and
- Figure 6 - is the fourth step of the tap hole measuring method according to the present invention.

Detailed description of the figures

[0013] As it can be seen from figure 1 the tap hole measuring device comprises a movable monitoring car 7, which is mounted on wheels 12 to allow its displacement on the platform 6. The car 7 is built of a welded metal structure, which allows the installation of a heat shield 14 to protect the operator from the high temperatures in the region close to the BOF, especially with an open tap hole 2. On the upper part of the car 7 a metal structure 13 supports a tubular coupling sleeve 10. The tubular coupling sleeve 10 has an inner diameter that allows the insertion of a steel rod 8. The rod 8, which can be shaped alternatively as a pipe and/or present different non circumferential cross sections, can be fixed in a releasable manner to the tubular coupling sleeve 10. At the outer end of the rod 8 a fan-shaped metal washer 9 is fixed through a mechanical or welded connection to the rod 8.

[0014] In the support structure 13 a laser measuring device 11 is positioned in a fixed manner in the vicinity of the tubular coupling sleeve 10. The laser measuring device 11 used is a commercial model with a range usually of 0,05 to 60 m and with a memory to storage the measurements. The laser measuring device 11 is positioned in the metal structure 13 in such a way that its measurement starts from the same point in a vertical axis as the end of the rod 8 abuts an internal backstop at the tubular coupling sleeve 10. This means that the laser measuring device 11 is positioned to measure exactly a distance in a parallel axis to the rod 8 starting from its end inserted in the tubular coupling sleeve 10.

[0015] If necessary counterweights can be placed at the bottom of the movable monitoring car 7 to compen-

sate the weight of the steel rod 8.

[0016] In figure 2 the movable monitoring car 7 can be seen from the front side showing the fan-shaped washer 9 and the heat shield 14.

[0017] In figure 3 the movable monitoring car 7 is positioned on the platform 6. The BOF 1 has its tap hole 2 in a direction which is parallel to the surface of the platform 6. The tap hole 2 has an external flange 4, with a corresponding planar surface perpendicular to platform 6. The rod 8 is inserted in and fixed to the tubular coupling sleeve 10. The rod 8 has a defined length, which can be, for example 3000 mm, or any other length that allows a safe handling of the device and a correct measurement of the tap hole length. At the opposed end of the rod 8 the fan-shaped washer 9 is mechanically fixed to the rod 8.

[0018] The tubular coupling sleeve 10 is adjustable in height at the support structure 13 which allows compensating any difference in height of the platform 6 in relation to the tap hole 2.

[0019] The measuring method of the present invention is performed with the measuring device described above and realized quickly with a short number of steps as shown in figures 3 to 6.

[0020] It can be seen that the BOF vessel 1 is tilted in a way that the longitudinal axis of the opening 5 of the tap hole 2 is parallel to the surface of the platform 6. The tap hole 2 has a flange 4 with a planar surface that is perpendicular to the surface of the platform 6. The rod 8 is inserted in the tubular coupling sleeve 10 and fixed in a releasable manner. The fan-shaped washer 9 is fixed at the opposed end of the rod 8. The distance between the fan-shaped washer 9 and the internal backstop at the tubular coupling sleeve 10, which corresponds to the length of the rod 8, is known and will be designated as "X". The laser measuring device 11 is positioned at the support structure 13 with its measuring point starting at the same point in a vertical axis as the abut point between the internal backstop of the tubular coupling sleeve 10 and the end of the rod 8.

[0021] In figure 4 the fan-shaped washer 9 is inserted with the rod 8 inside the tap hole 2 opening 5. The movable monitoring car 7 is moved with its wheels 12 over the platform 6 by an operator in the direction of the BOF vessel 1. The washer 9 having an outer diameter bigger than the opening 5 of the tap hole 2 results in a resistance against its insertion movement of the washer 9 in the opening 5. This resistance ceases in the moment the washer 9 passes the opening 5 and is inside the BOF vessel 1.

[0022] In figure 5 the movable monitoring car 7 with the rod 8 and the fan-shaped washer 9 is pulled back until the fan-shaped washer 9 faces the inner wall of the refractory lining 9. As already mentioned the outer diameter of the fan-shaped washer 9 is bigger than the diameter of the opening 5 of the tap hole 2. At this moment a resistance against the pull back movement is felt by the operator and the movable monitoring car 7 is stopped.

The laser measuring device 11 is activated and a measurement is made with the laser beam pointing at the planar surface of the flange 4. The distance measured will be designated as "Y" and can be stored at the memory of the laser measuring device 11.

[0023] The calculation of the thickness of the refractory lining 3 inside the BOF vessel 1 is performed in a simple way. The distance from the planar surface of the flange 4 to the internal metal wall of the BOF vessel 1 is known from its project and will be designated as "Z".

[0024] The formula for calculating the thickness "T" of the lining 3 at the tap hole region reads as follows:

$$T = X - (Y + Z)$$

X, being the length of the rod 8,

Y, being the distance measured by the laser measuring device 11.

Z, being the project distance between the planar vertical surface of flange 4 and the inner metal wall of BOF vessel 1.

[0025] After the measurement process, as shown in figure 6, the rod 8 is released from the tubular coupling sleeve 10. The movable monitoring car 7 is pulled back from the rod 8. The rod 8 and the fan-shaped washer 9 are disposed inside the BOF vessel 1 and will be mixed to the metal scrap used for the subsequent heat. The BOF vessel 1 is tilted back to its vertical position.

[0026] Having described one preferred embodiment, it should be understood that the scope of the present invention contemplates other possible variations, being limited only by the content of the attached claims, including possible equivalent solutions.

Reference numbers

[0027]

- 1- BOF vessel
- 2- Tap hole
- 3- Refractory lining
- 4- Flange
- 5- Opening of tap hole
- 6- Platform
- 7- Movable monitoring car
- 8- Rod
- 9- Fan-shaped washer
- 10- Tubular coupling sleeve
- 11- Laser measuring device
- 12- Wheels
- 13- Metal support structure
- 14- Heat shield

Claims

1. Tap hole measuring device for a BOF vessel used in the steel production, the BOF vessel (1), comprising an internal refractory lining (2) and a tap hole (2), which includes an opening (5) and a flange (4) with a planar surface, **characterized in that** the measuring device comprises a movable monitoring car (7), a steel rod (8) with a fan-shaped metal washer (9) mounted on one end of the rod (8), the other end of the rod (8) being fixed in a releasable manner in a tubular coupling sleeve (10) of the movable monitoring car (7) and a laser measuring device (11) placed in the vicinity and aligned parallel to the rod (8) on the movable monitoring car (7).
2. Tap hole measuring device according to claim 1, **characterized in that** the movable monitoring car (7) has a metal support structure (13) to receive the tubular coupling sleeve (10) in an adjustable manner.
3. Tap hole measuring device according to claim 2, **characterized in that** the metal support structure (13) receives the laser measuring device (11) placed in the vicinity of the tubular coupling sleeve (10).
4. Tap hole measuring device according to anyone of claims 1 to 3, **characterized in that** the movable monitoring car (7) has a heat shield and wheels (12).
5. Tap hole measuring device according to claim 1, **characterized in that** the steel rod (8) can be shaped as a pipe and/or present non circumferential cross sections.
6. Tap hole measuring device according to claim 1, **characterized in that** the laser measuring device (11) has a range from 0,05 to 60 m.
7. Method for measuring the thickness of a refractory lining in a tap hole (2) of a BOF vessel (1) using the tap hole measuring device defined in anyone of claims 1 to 6, the method comprising the steps of:
 - tilting a BOF vessel (1) to place an opening (5) of a tap hole (2) parallel to a platform (6);
 - inserting and fixing in a releasable manner the free end of a rod (8), with a fan-shaped washer (9) placed on the opposed end, in a tubular coupling sleeve (10) of a movable monitoring car (7);
 - moving the movable monitoring car (7) in the direction of the BOF vessel (1) and inserting the fan-shaped washer (9) and the rod (8) inside the opening (5) of the tap hole (2);
 - stopping the movable monitoring car (7) when no resistance against the insertion movement of the fan-shaped washer (9) and the rod (8) inside the opening (5) is felt by the operator;

- pulling back the movable monitoring car (7) until a resistance against this movement is felt by the operator;
- activating the laser measuring device (11) with the laser beam measuring the distance until the planar surface of the flange (4) of the tap hole (2);
- disconnecting the rod (8) with the fan-shaped washer (9) from the tubular coupling sleeve (10);
- pulling back the movable monitoring car (7) away from the rod (8);
- discarding the rod (8) with the fan-shaped washer (9) inside the BOF vessel (1).

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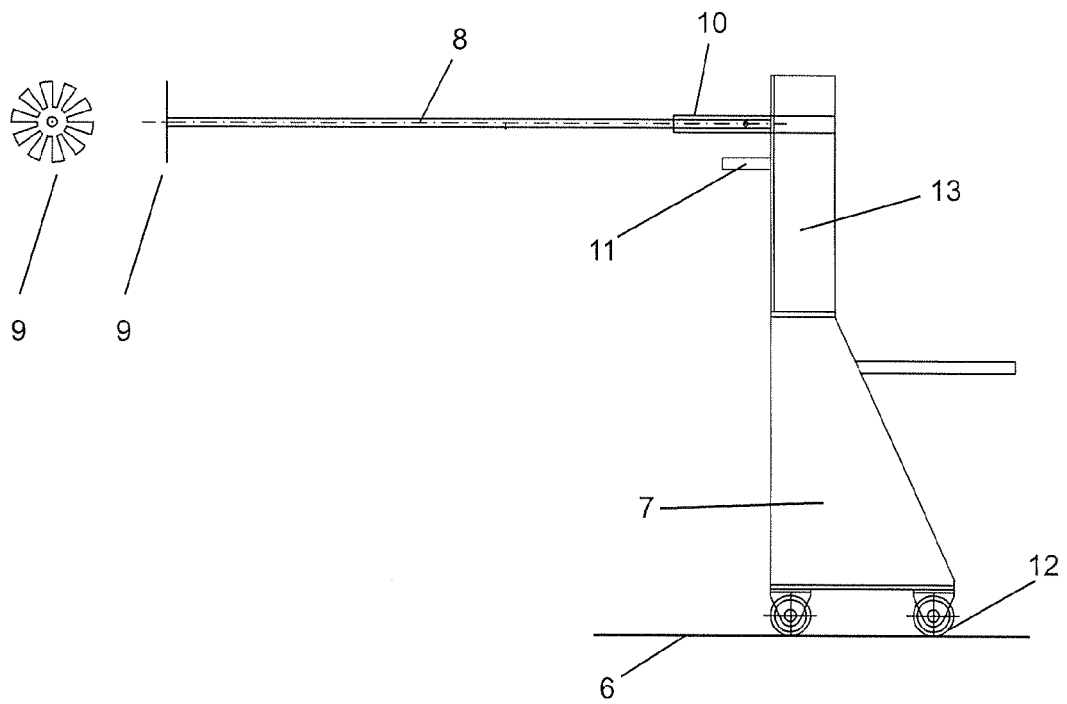


FIG. 1

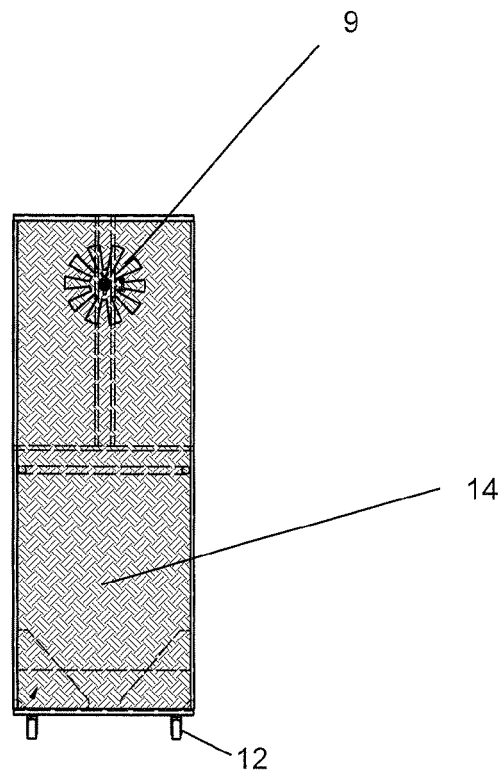


FIG. 2

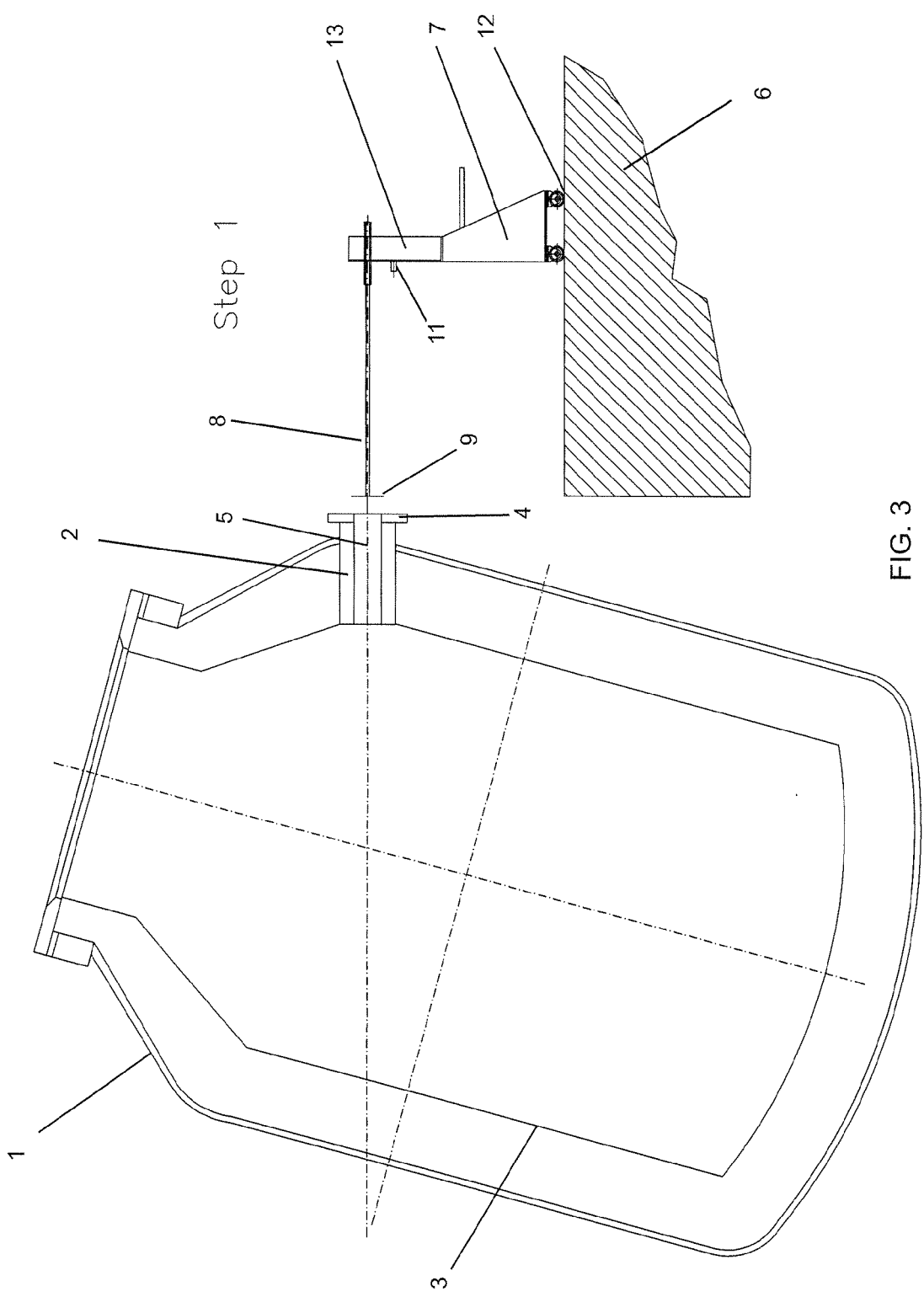


FIG. 3

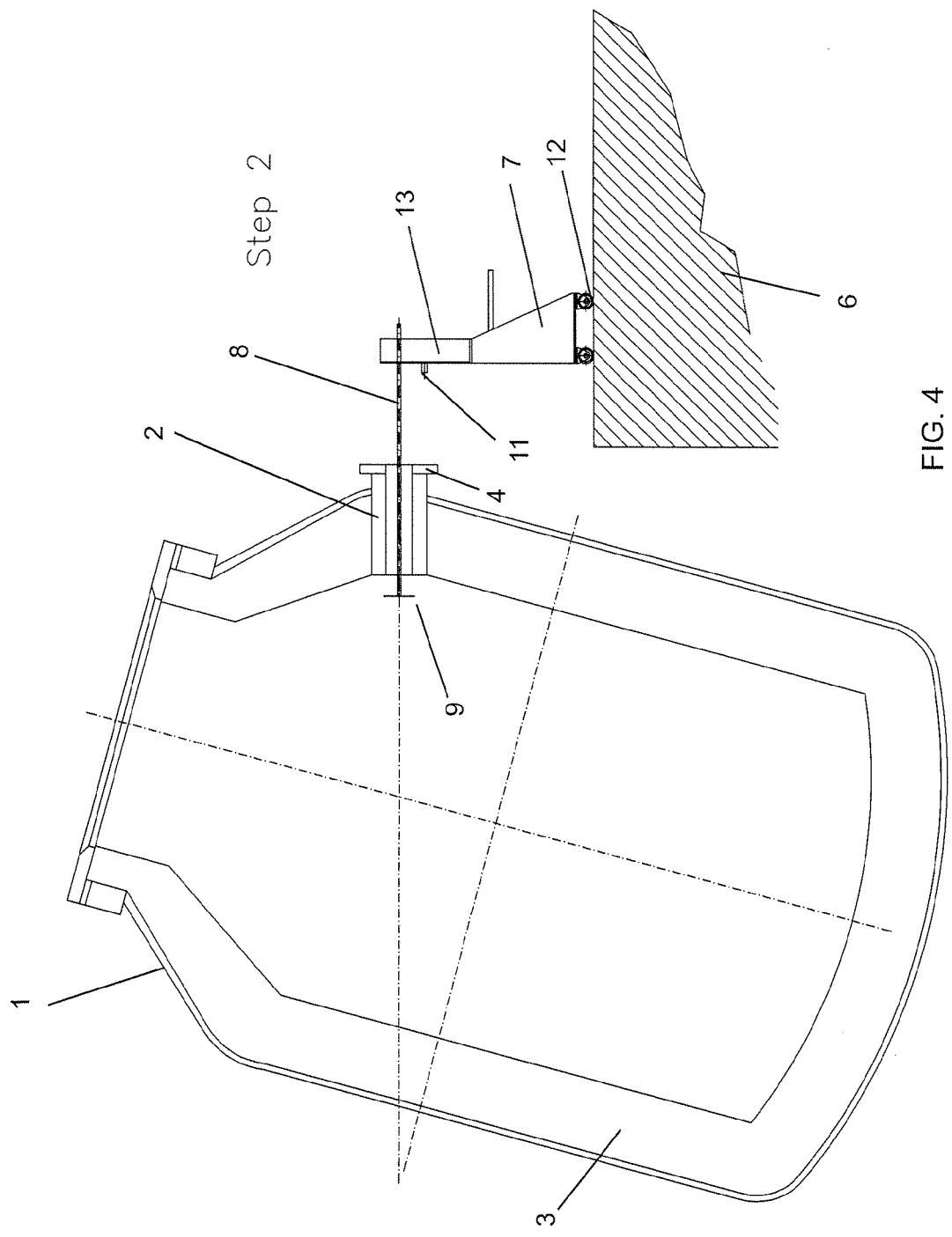
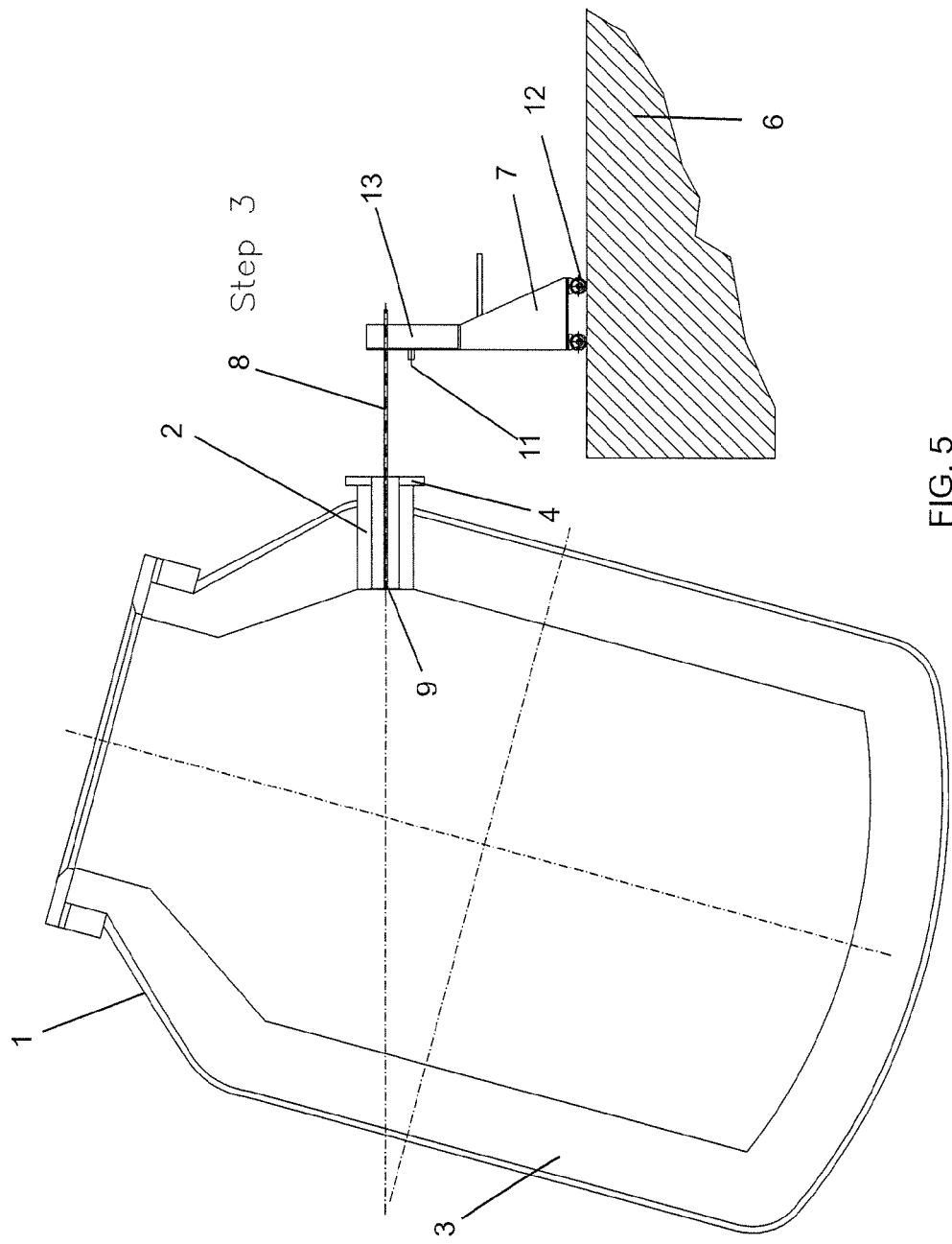


FIG. 4



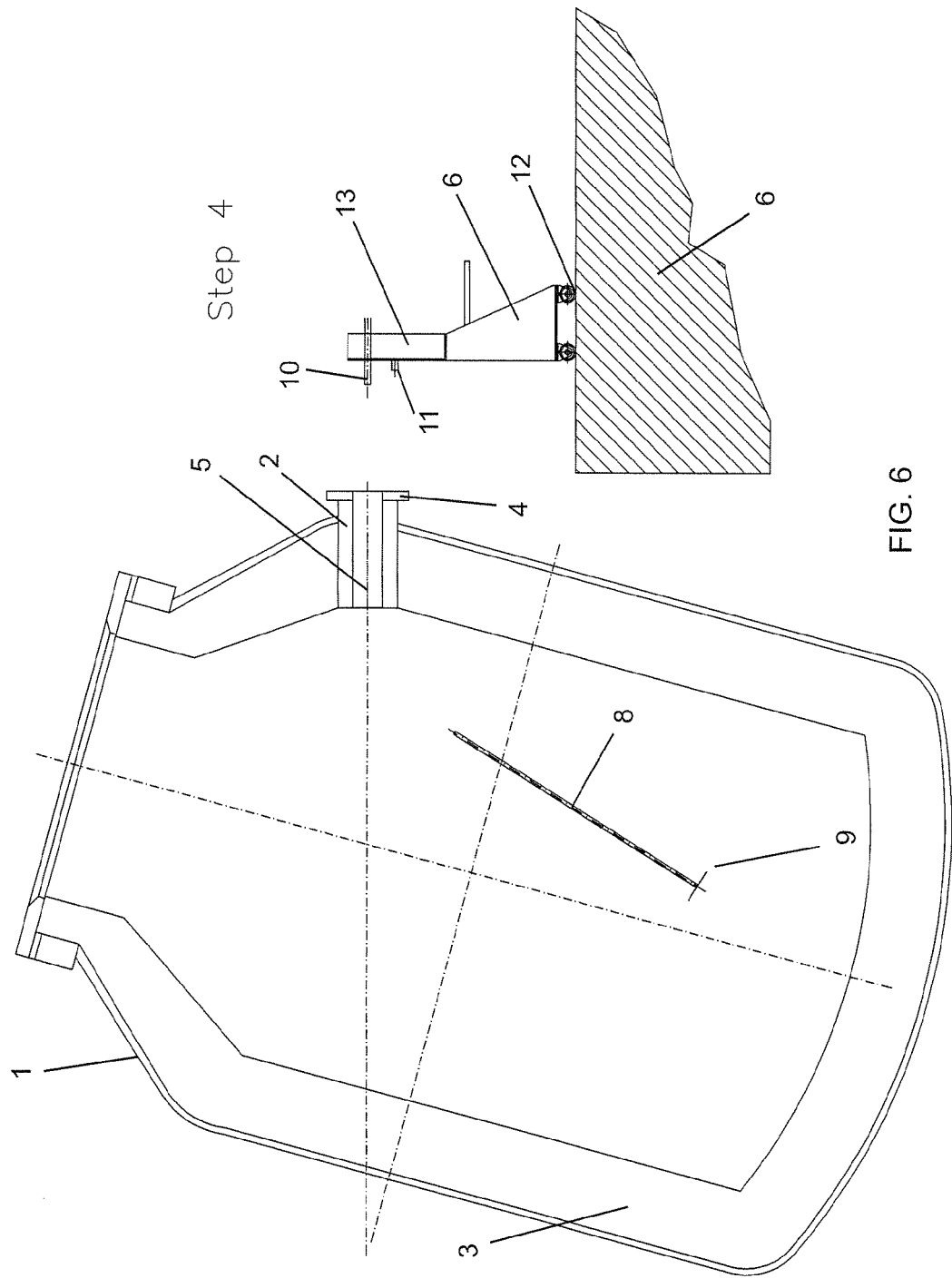


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 13 17 6459

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CN 202 272 911 U (ANGANG STEEL CO LTD) 13 June 2012 (2012-06-13) * figures 1-4 * * paragraph [0004] * -----	1-7	INV. F27D21/00 C21C5/46
			TECHNICAL FIELDS SEARCHED (IPC)
			F27D C21C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 November 2013	Examiner Peis, Stefano
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 17 6459

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18-11-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 202272911	U	13-06-2012	NONE

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